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Evening Meeting.

Monday, May 20th, 1878.

LIEUTENANT-GENERAL SIR GARNET J. WOLSELEY, G.C.M.G., &c., &c.. in the Chair.

For his opinion see page 38.

MILITARY RAILWAYS.

By JOHN L. HADDAN, ESQ., F.R.G.S., M.I.C.E., Officer of the Medjediè, &c., and Ex-Engineer-in-Chief, Ottoman Government.

THIS subject may be broadly divided into two distinct classes, viz.: transport railways, as represented by existing lines; and field railways, which must be entirely created. The first entirely under civil control, and the latter purely military.

A transport railway, sufficiently large to forward an army corps complete, including artillery and cavalry; cannot, it is self-evident, be constructed during the short duration of a modern campaign: since, without the line was of considerable length, it would have no *raison d'être*, since marching would be more expeditious. All that can be done in this direction is to adapt existing railways to suit military requirements at the minimum of inconvenience to commerce.

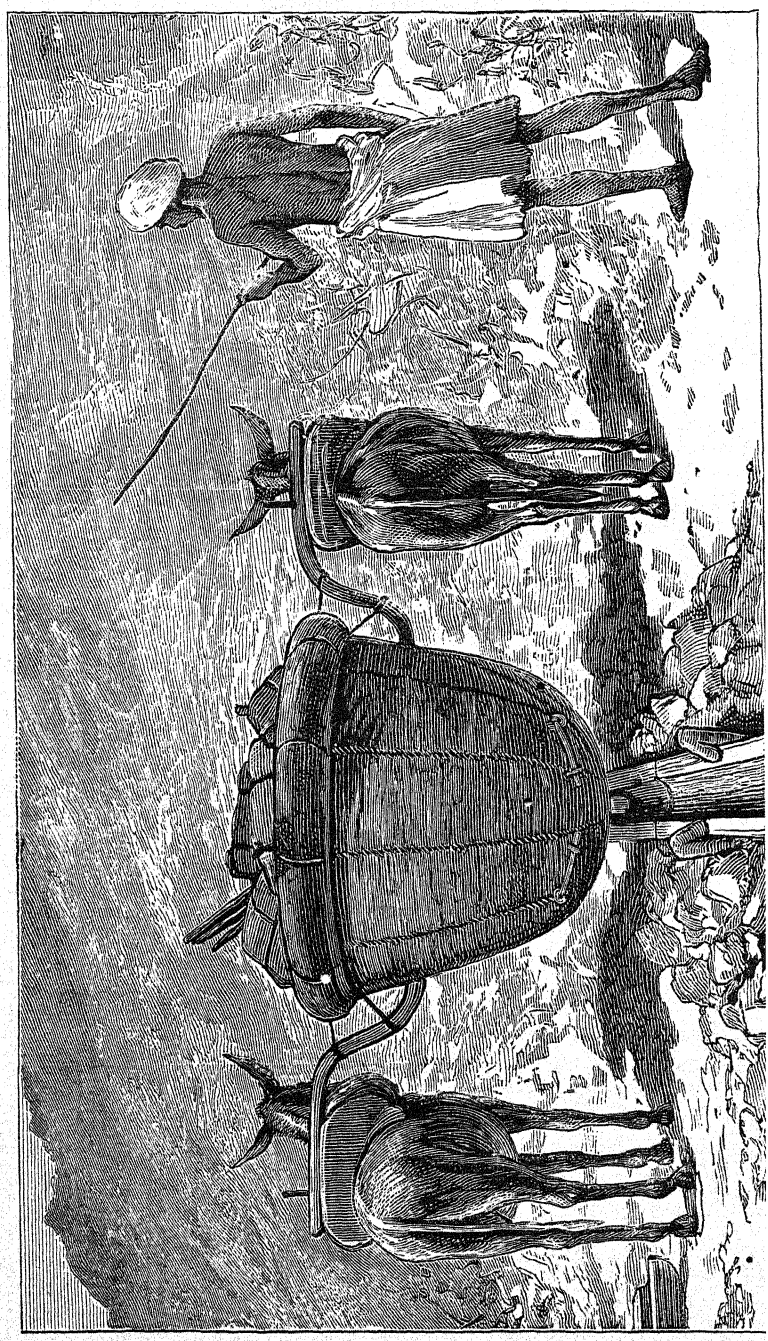
The first step is to divide up the whole of the rolling stock into trains, each distinguished by a prominent mark; and each having its terminal place for loading and unloading assigned to it, as also its own special staff. These trains, once formed and classed, are never to be disintegrated; since, by detaching the waggons, confusion is bred: the value of which may be gathered from the inclosed official report on French railways (see Table No. I, page 25). This Report shows that, owing to the difficulty of sorting waggons as units, and making them up into trains, in a crowded because concentrated terminus; the average quantity of rolling stock available for use at one time is only 10 per cent. of the whole supply.[1] The number of waggons which should form a train will depend upon the worst grades of the line, the length of the sidings, and the size of the army to be transported; but a fair average would be about thirty waggons.

Thus, at one swoop, we reduce our working stock to a strictly necessary active minimum, and moreover increase the unit thirtyfold in size; while we offer the minimum of obstruction to the ordinary traffic.[2]

[1] The cost and trouble of sorting waggons is represented in France by the difference of tariff charged for "grande et petite vitesse" goods, which is also 10 to 1. Both goods however travel in the same trains; but one class are dispatched in a hurry, and the others are delayed to be economically stowed.

[2] The existing system of relying upon the country itself for supplying military transport, is economically wrong. The damage done thereby is simply incalculable; when, as is too often the case, animals are destroyed wholesale, and trade currents turned for ever from their usual course.

UNITED SERVICE INSTITUTION OF INDIA, NEW DELHI
Acc. No. 11275
Dated 25-5-64



The waggons and carriages used should be reduced as much as possible to one type, the perfection of utility being a plain truck or platform; it might be necessary therefore to remove the upper works of many of the covered waggons or carriages, or what would be better, construct the stock on all strategic lines, so that the under-frames were independent of the rest of the vehicle.[1]

Our trains having been made up, it becomes necessary to insure rapid loading and discharging, that the freight should likewise be converted into units and treated as it were like passengers; since it is not advisable to attempt the usual unsatisfactory practice, and endeavour to extricate the required type of waggons and bring them piecemeal to the heterogeneous mass of goods. A hide and seek lottery with mostly blanks.

These baggage units consist of boxes mounted on friction rollers, their size being about 7 feet long, by 4 feet, by 5 feet, of a capacity of about one ton average. Five of such boxes would go to a waggon, and their contents might consist of as many different elements without causing the least confusion. They might with advantage be cylindrical.

Nothing of any sort should be sent loose, but packed in those special freight boxes; so that, without breaking bulk, the most delicate stores might be sent from Woolwich to the north-west Indian frontier: although the sea be crossed, railways of two gauges used, and perhaps river navigation and common road transport required, to boot. The type of box to be used should be one of strong but simple construction, of a size not only suitable to the general military requirements, but also available when emptied for as many extraneous purposes as possible. The size before mentioned, which is rather larger than a palanquin, should answer well; since it is available as a horse-box, ambulance carriage, and general cart, when mounted with spare artillery wheels: for which its sides should be prepared.

They should be air-tight, and contain enough air space to render their debarkation or transport by flotation possible; or, when empty, their being employed as pontoons, or filled with stones, &c., for temporary quay blocks, &c. When taken to pieces, their sides form building slabs of a very handy size for temporary structures of all kinds.

These cases should be made of a foundation of wire trellis work, enfolded in a sort of papier maché composition. The strength of such a construction is not readily credited; but I may mention that a fire-proof dome has been made to St. Paul's Cathedral on a similar plan, which is only three-eighths of an inch thick, Portland cement being used in lieu of papier maché. There is a small specimen on the table, which though of cement no amount of hard usage would hurt.

When the trucks are specially constructed for military purposes then two lines of bars or light rails are fixed longitudinally on their platforms, so that, by means of a rope and winding gear on the engine, two whole trains of boxes may be pulled *endways* on to the train of trucks, and thus the loading be very rapidly performed; but, for ordinary purposes, the boxes would be rolled on sideways from the

[1] This system is gradually coming into use in England. Instance the Taylor furniture vans, and the live fish tanks sent to Billingsgate Market.

usual goods platforms, or up temporary inclines made (say of spare rails) for the purpose.

These boxes, their working staff, and all forms, &c., used, should each bear a colour (or uniform), or other forcible means of readily distinguishing their class; so that every one in the Service should be able to recognize at a glance, the different main classes of stores: red for ammunition, white for rations, &c., &c.

The spots selected for loading and unloading should be echeloned as much as possible, and the traffic should be by no means conducted to one large depôt, as is the civil custom; the arrival and departure points should also be as far apart as possible, even to the extent of being on another line of railway, if available.

The various descriptions or classes of stores would thus have their own transport depôts and trains, and would be in a position to execute any indent made upon them without clashing with each other. No sheds would be required, since the stores are packed in the freight boxes. The last few miles of the railway would thus form a detached string of roadside depôts.

Many of the Indian strategic lines are only single tracks, and to these the box system might with advantage be applied, even for civil purposes; sorting being very expeditious by these means, full waggons always assured,[1] and the evils of break of gauge much modified. On single lines, owing to the numerous passing, or, more correctly speaking, *waiting* places, the management is anything but simple. Example: On the Great Indian Peninsula, during the famine year, the coal consumption alone was increased 10 per cent. (3·74 lbs. per train mile), simply from the amount of *waiting* that had to be undergone at the passing-places (see Captain Oldham's, R.E., report). To avoid this inconvenience, the line, if a short one, should be used as an up and down line alternate days; or, if a long one, should be divided administratively into 100 mile sections, and worked independently, on the same system. A weak double line is for this reason far preferable to even a broad gauge single line—the feeble but constant action of the one, more than compensating for the gross but intermittent efforts of the other, with a corresponding advantage in regularity and celerity of dispatch. For military purposes it is, therefore, a *sine quâ non* that the line should have a double track. (See Discussion, Mr. Shaw, page 35.)

The working models of this system, $\frac{1}{10}$th full size, showing the boxes working as carts, pontoons, or freight boxes, may be seen in Paris; but the system is so simple that I think it can be clearly understood without reference to them.

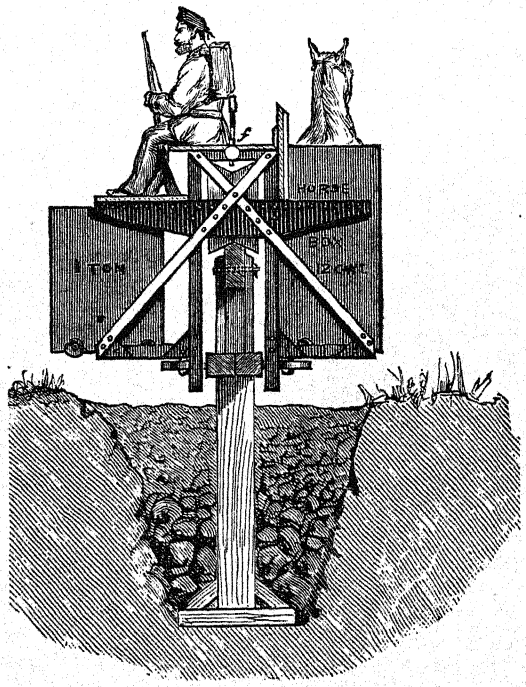
Field Railways.

No one, intimately acquainted with the ordinary railway construction and management in all its details, could possibly expect such a system to work in a campaign.

[1] The Smyrna and Cassaba Railway, in Turkey, earns 7 per cent. by never dispatching a partially filled truck. They run about two goods trains a day, but always wait to fill up.

The sinking of the earthworks and the constant ballasting of the road, which all new lines incessantly require; should be enough of itself to condemn this system of construction.

In additions, the surveys and levels are very tedious; and to save cube, the choice of route is so circumscribed as to modify in a great measure the advantages of the railway.[1] Captain Luard, an authority on the subject, states that the Prussian field railway at Metz took 200,000 days' work to execute twenty-two miles on very easy ground; and yet the accidents from settlement were frequent, and the engine could never draw more than four waggons and practically did no



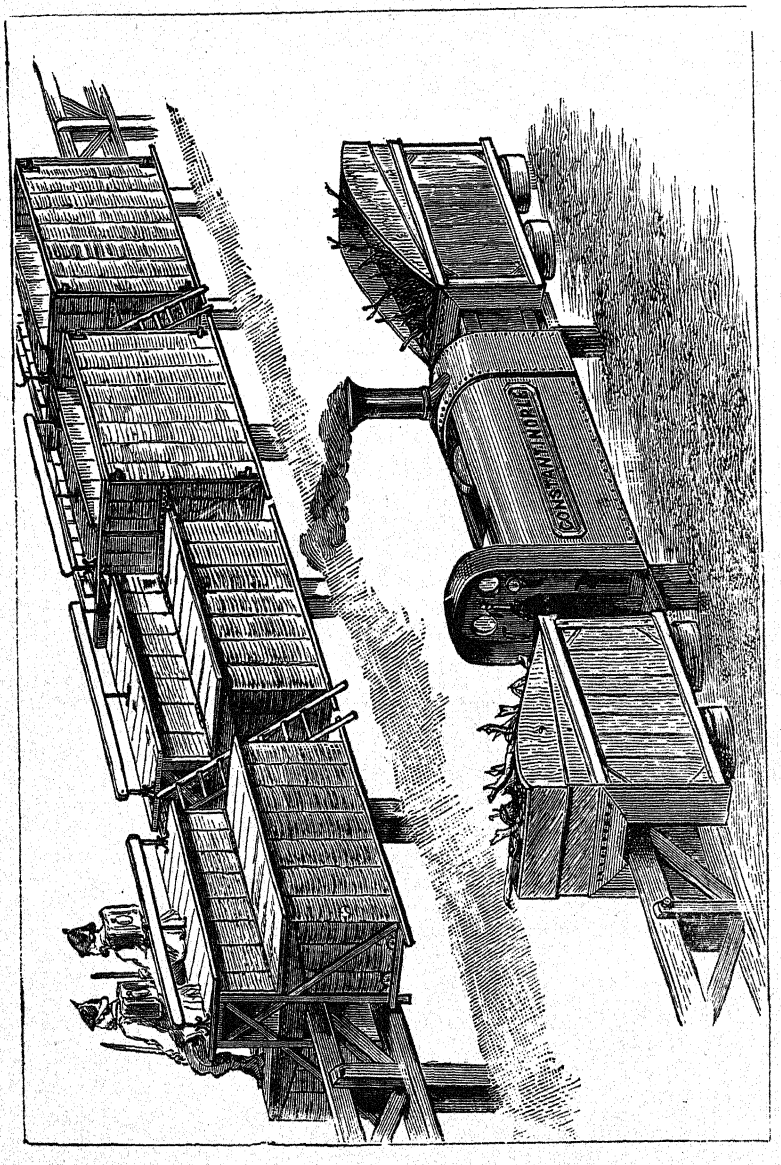
CROSS SECTION—MILITARY RAILWAY.

This half shows the skeleton carriage as arranged for both passengers and boxes of goods. The boxes are mounted on wheels; one is shown partially withdrawn.

This half shows the same carriage arranged to carry cattle-boxes: the passenger flooring being simply turned up, and the box rolled on as before.

(*From "The Graphic."*)

[1] Sir Garnet Wolseley says a military railway ought to be able to obey orders and go anywhere and everywhere.


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work; although the line was in connection with the existing railway system, and was in reality but a branch.

With earthwork railways their progress of construction is limited by local conditions; but where the whole of the structure is producible in the workshops of the world, it would not be extravagant to say that thousands of miles of "Pioneer" could be constructed in as many weeks as ordinary railways would require years, and with a chance of subsequent success in earning a dividend inversely proportionate to the time occupied in their construction.

Lieutenant Willan describes the difficulties met with in Abyssinia, difficulties entirely inherent to the railway system, and certainly no fault of his or the Administration. First, a natural grade of 1 in 40, which a horse and cart would make nothing of, but work at a gallop; had to be tortured into one of 1 in 60, to suit the weight (tractive power) of the engines supplied; the rails arrived without the spikes, the curved rails would not fit the curves of the earthworks, nor would the fish-plates register on curves without cutting the rails; while the engines strained as they were in transport, and by the roughness of the track, gave endless trouble: details which I can thoroughly appreciate, since in the *Paris* tramways we could not keep an engine three days in proper working order, owing to the comparative roughness of the road. Each mile took ten days to construct, and each train only weighed 40 tons gross, although the gauge was the Indian 5′ 6″.

In Ashantee, where, with an unhealthy littoral, a field railway would doubtless have been a great boon, the railway turned out a white elephant; and the great portion of the materials were never even landed.

In the Crimea, a comparatively speaking surface line was made at an apparent saving *in time*; but, with grades so steep, the limit of the locomotive was soon reached, and then horses had to be called in; while a short piece of one-third of a mile on 1 in 15 had to be worked by a stationary engine. Thus, as the strength of a chain of communication depends upon the value of its weakest link, it is not surprising that with three distinct systems, each of different supplying speeds,[1] it should have taken a staff of 1,000 men to supply 700 tons daily over a line of a few miles in length. The attempted Austro-Bosnian occupation railway records another failure of ordinary railway construction for military purposes. The bulk and weight of the materials proved fatal both in land and water transport.[2]

All these failures are due to the vicious principles adopted for railway traction, which have been protested against from the earliest days by Vignoles, Bridges Adams, and others; but financiers object to reform, and mechanics positively enjoy showing their marvellous skill in defying natural laws, even to the extent on railways, of supplying

[1] Speed is of no importance in military transport, since it only affects the first delivery: while the all important regularity is more easily attainable at low speeds.

[2] In a paper read before the Society of Engineers, the author published elaborate tables, showing that every road surface material, from a steel rail to loose gravel, possessed a special incline of its own on which it was supreme. Thus a rail was supreme on grades of 1 in 250, while gravel enjoyed 1 in 20; but with all the wheels coupled, and the train self-propelled (see pages 20 and 22) the smooth rail reached its zenith on 1 in 7.

engines of such a weight, that the disintegration point of the rails used has been positively exceeded; and yet their engine can on steep grades be beaten as a tractive animal by a common ass. The ordinary locomotive represents a power with the bulk of an elephant, but only the strength of a horse; a steep line in the Mauritius requiring three tons of engine per horse-power developed.

Now, perhaps, that the financier's day of railway pushing is over, and that Indian railways have only paid the State one per cent. interest on their capital,[1] and that the colonies show similar financial failures, and famines areraging all over the world; simply from want of sensible means of communication and from the exhaustion of indigenous animal transport: it is to be hoped that the "weight is power" incubus of our railway system will meet the discredit it deserves.

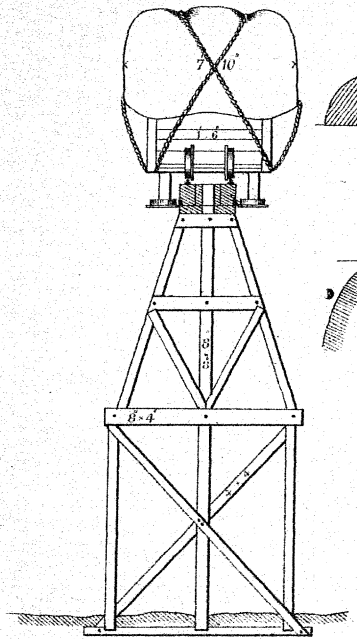
The proposed expeditionary railway, now in store at Woolwich; consists simply of wooden sleepers and 35 lbs. Vignoles' rails, an assortment of iron floor joists being supplied for bridges. The engine, however, is a novelty; was invented by the late A. Handyside, and is being perfected by Messrs. Fox, Walker, and Co., of Bristol. It consists of an ordinary locomotive, weighing about 13 tons, fitted with claws to grip the rails; and it is provided with 300 feet of wire rope, by which it is enabled on a stiff incline to pull up the train after it in successive stages of 300 feet each, the engine running ahead each time for this purpose. This system would answer well enough if a line of country *could* always be found conveniently composed of flats and very steep inclines; but what would be done on moderately steep inclines? If this engine worked the average grades in the usual manner, it could not take a paying load; and if it worked by the rope, the operation would take so much time (especially if there were many curves, as is generally the case on surface lines in rough countries); that the former, by repeated trips could do the same duty in the same time: so *cui-bono*. In addition no permanent way could be laid strong enough to stand the concentrated pull for any length of time. This system, like the Fell, the Righi, and so many others; is only at home when working at extremes.

The Handyside engine however proves one most remarkable fact, viz.: that steam power in excess of a corresponding amount of adhesion or weight, is of no possible use in a locomotive; for when unlimited adhesion is obtained by anchoring the engine down (or by any other means), any amount of steam power which can possibly be crammed into the engine, is as decidedly utilizable as if the engine were a stationary one. See Table No. II, where 40 horse-power is all the steam which can be assimilated by an 8-ton locomotive or gravity engine; while the Pioneer or grip engine of like weight per coupled wheel, absorbs the whole of the horse-power supplied—in the case in question, 480 horse-power. The arrangement by which this is effected is described in detail on page 16.

We may therefore accept as a law, that in a gravity engine the tractive power obtainable is not a question of steam power, but one of weight alone;

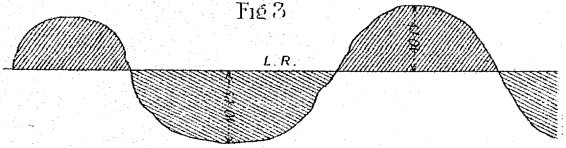
[1] Mr. Fawcett, M.P., made this statement in the House of Commons, on the discussion of the Indian Budget for 1877.

SHEET OF DIAGRAMS

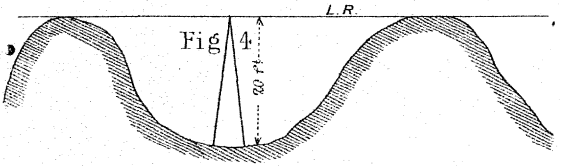


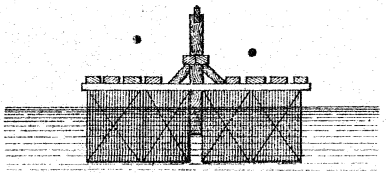
FELL 20 FT TRESSEL
Fig 1.

Section of EARTHWORK *Railway*
Banks & Cuttings compensating
Fig 3



Identical Section VIADUCT-*no Earthworks.*





PONTOON OF PIONEER FREIGHT BOXES.
Fig. 5.

Fig. 7.

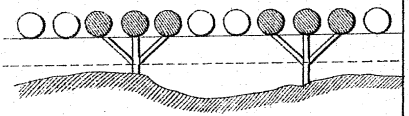
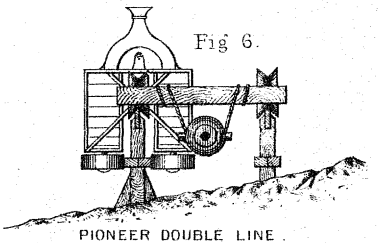


Fig 6.



PIONEER DOUBLE LINE.
Being used as a single line so as to transport a 7 ton gun.

while in a grip engine the contrary is the case: steam being absolute, and concentrated gravity an element which is positively pernicious.

The value of the substitution of steam for weight as a motive power is immense; a glance at Table No. III, showing that a premium of even 240 fold in tractive power is obtainable. In reality, the grip is without limit.

By enabling grades of 10 per cent. to be worked with similar loads to those now available on 1 in 200 (a fair average English grade), we bring mountainous countries within the pale of the steam-horse: and, moreover, diminish to a minimum those colossal earthworks which, especially when executed by hand, as a military railway would be; would absorb, according to Captain Luard, at least one-tenth of the fighting force. I myself judging from civil experience should feel inclined to put it much higher, as rapidity of execution is so important an element.[1]

It is self-evident that a field railway must be a temporary structure, the whole of which may have to be brought from a distance. Consequently the weight and number of its parts must be studied with a care certainly not inferior to any other military transport equipment, since rapidity of construction depends entirely upon the amount of work which has to be done on the ground, such work including also the carriage of the materials. It must also be readily destroyable in case of retreat.

A reduction of the weight of the engine to that of the standard decided upon for the waggons, enables the freights of such trains to be spread out over any desired length. This lightens the road to a corresponding extent, without diminishing however its total carrying power.

Thus, miniature railway construction becomes feasible, which is not the case with railways proper; where a reduction in gauge and first cost, means a corresponding augmentation in working expenses, consequent on a reduced train load.[2] In India, the broad gauge transports 300 tons for the same cost as the narrow gauge carries 170 tons. In fact, in attempting miniature railways on gravity principles, the train soon becomes all engine. Although expense is no object in a military railway, yet it is useful to consider the working charges when cost means weight—as it does with the ordinary railway. (See Table No. III.)

The Pioneer engine is however always constructed on the same scale as its waggons, which govern its size. In this case it is $1\frac{1}{2}$ tons per axle, the maximum weight economically workable on a light elevated road; the practical minimum is about half a ton, representing 250 tons per

[1] Seeing that the Transvaal was as big as France, and yet had only 50,000 whites to cultivate the whole of it, Sir Theophilus Shepstone showed himself a great statesman in exempting the Boers from military service, because *their services as cultivators were far more valuable.* In India, and elsewhere, this should not be forgotten, since the remark applies with equal force to both railway and road earthwork construction; a case in point, Mr. Sandford Fleming, the Colonial Government Engineer, states that, on the whole 3,000 miles of proposed Canadian Inter-oceanic Railway, not more than 30,000 settlers are to be found.

[2] On the Paris Tramways, running *one* car with steam involved a loss of 7 per cent.; with two our dividend was 20 per cent.

diem,[1] on which scale the road can be executed in iron, in the best style and including rolling stock for 750*l.* per mile, f. o. b. The gross weight of the Pioneer attenuated train may be 100, 200, or even 400 tons, in fact, the same as the broad gauge: but the goods on this system travel as it were Indian file instead of in "sections."

Elevated or post and rail railways were first proposed by a Mr. Palmer, in the year 1821, and have been erected in various parts of the globe, more especially in America, but always only on comparatively level ground; *since a gravity engine of sufficient weight for inclines was out of the question on such a structure.* One was also put to work at a copper mine near Buyukdéré, on the Bosphorus, and a very fine example of a one rail railway, on posts 17 feet high, was erected on the crowded quays of Lyons: it was, however, worked by a stationary engine. Another was erected on the Black Sea coast the carriages being propelled by men working cranks.

The last railway of this sort, *also constructed on gravity principles*, was tried by Mr. Fell, at Aldershot, and was very ably described by Captain Luard, in a paper read in 1873 before this Institution.

Its failure was certain, for on such a structure a gravity engine would have to be four times as heavy to do the same work as on an ordinary railway; because, from the fact of cuttings not being used to compensate the banks in forming grades, inclines of say twice the steepness would be required to grade the same line of country. See Sheet of Diagrams, Figs. 3 and 4, where, in lieu of a 10-foot bank, compensating a 10-foot cutting; a 20-foot viaduct is required to obtain the same grade: or, if a 10-foot viaduct were substituted, grades would have to be so steep that the engine would have to weigh fourfold. Thus at Aldershot on easy ground, it was necessary to use 20-foot trestles to secure a grade of 1 in 50, and a paltry gross load of only 22 tons or say 14 tons net: the weight per axle being the same as the Pioneer. Now such lofty posts are not economical, since a 5-foot post will support about four times the amount which a 20-foot post would do; consequently their habitual use is not practical. These trestles have also the additional inconvenience in a ready-made railway, of requiring a proportionately greater stock of type trestles of various heights, whose component parts all differ both in size, weight, and angle; and, therefore, cannot be used in common.

On this system there could be no universal standard trestle applicable, or even readily convertible, to any section of country, even an easy one; and most elaborate levels, both longitudinal and transverse (as in setting out side widths on a railway) would have to be performed on the proposed site of each trestle, and guys and other tackle used for the erection of all but the smallest sizes. On curves, more especially if a 3ft. 6in. gauge were used, as suggested by Mr. Fell, not a piece would fit; as the right and left beams and rails are either longer or shorter, especially on a road where the curves throughout had a tendency, say more right than left. The Sheet of Diagrams, Plate 5, Fig. 1,

[1] The South Indian narrow gauge railway, 600 miles in length, only transported 162 tons per diem in the year 1877. It cost 6,500*l.* per mile.—See Mr. Juland Danvers' admirable report.

shows a "Fell" 20-foot trestle and waggon. It is a facsimile of the published drawings accompanying Capt. Luard's paper, before referred to.

The objects sought to be attained by the advocates of elevated railways are to avoid close contact with the surface soil, so as to eschew its endless vagaries under climatic influence.[1] To expose also only the minimum of running surface (the reverse of a carriage road), and render it independent of the effects of the weather, so fatal to that regularity of delivery of supplies, removal of wounded, &c., &c., upon which the efficiency of the whole military machine is entirely dependent.[2] The support derived from the soil is therefore sought for in the Pioneer system at a few feet under its surface—below weather mark as it were—while the prohibitive cost which would naturally follow the use of few supports and long spans, in lieu of the many supports afforded by closely set sleepers, is avoided by the following economical expedient.

Just as a girder bridge may be rolled out entire over any number of piers, so do I convert my train into a *rolling* girder by the use of carriages of a length equal to about two spans of the permanent way; the carriage being fitted with superfluous wheels to act as rollers, each taking up the whole burden in turn and relieving the others. In the sheet of Diagrams No. 5, Fig. 7, the wheels shaded black are entirely supporting the load, and the rail under the other wheels may therefore theoretically (and even in some cases practically) be entirely cut away, and thus allow of free cross traffic. In fact, in lieu of using a fixed girder (in the shape of permanent way), miles upon miles in length; I make use of a travelling girder but a few yards long (in the form of a stiff-backed train). *Q.E.D.*

Thus instead of the permanent way requiring to be constructed of weighty and very substantial materials—the short perambulatory girder which constitutes the train absolves the permanent way of its interminable girder responsibilities; the Pioneer practically carrying her bridges, all but the piers, along with her.

The Pioneer, after thus reducing, on common sense principles, the necessary strength of the road about 90 per cent., next attacks the amount of work usually required on the ground; this ordinarily consists mainly of earthworks and bridges. Now, the great obstacle to military success in constructing railways is indubitably earthworks, which demand the most tedious studies, restrict the route chosen, interfere with the water sheds and nature generally, has to be moved hundreds of ton miles in the aggregate, is retarded or stopped by the weather; and lastly, requires endless variety of treatment, and even then can never be depended upon to stand, especially when green. The time wasted moreover in their construction, is simply golden. Unlike however these ordinary roads or railways, which often afford facilities for an invasive force, the Pioneer can be utterly destroyed in a few hours.

All post and rail railways claim the advantage of abolishing earthworks; but the Aldershot railway employed cuttings, the earth from

[1] At the Kilburn Agricultural Show, Mr. Fowler's miniature engine was rendered useless by the country hinds scraping their clayey boots on the rails, and by one rail sinking below the surface of the ground.

[2] An excess of stores collected at the front to allow for contingencies is not only a complication, but also risky in the event of retreat.

which was not utilized at all: and I, therefore, venture to think these and other conditions are really only practically met by a *one* rail structure like the Pioneer. It skims the ground without disturbing it, and having no gauge, readily suits itself to the sharpest curves, even on sidelong ground. The posts used for military railways have one constant height of 7 feet, three feet of which must always be above ground; so that it leaves a 4-foot margin for such minor inequalities in the soil as a grade of 1 in 10 cannot eradicate, and those are but few indeed. These inequalities I found from experiment, but rarely exceed 1 foot between any two posts; but I prefer to use posts of one type, in lieu of bothering with three types of posts, viz., 5, 6, and 7-feet ones, as would be done for economy in civil cases. The stability of the structure is assured, partly by sinking into the ground (440 holes in a mile) and partly by footings, buried or superficial. The holes are of varying depth so as to save cutting the posts. The structure may be either of wood or iron, or of both combined; but certain authorities prefer wood for military purposes, since omissions or damages are more easily repaired. The upper rail is formed of two planks on edge breaking joint with each other anywhere and bolted together sandwich fashion; but an iron deck beam or rail may be used in lieu. The lower or grip rail, which forms a continuous chain as it were for the grip engine to pull at, is in oak, notched to hold firmly to the posts and struts. These deep notches, occurring with regularity at every 4 feet, admit of ready but not too facile bending on curves, the maximum being fixed at 100 feet radius, or about 2 inches per bay. The saw cuts at every 8 inches are for the same purpose. The breaking strength of the structure is 20 tons, its weight about 80 tons per mile complete. The cube capacity in round numbers is 4,500 cube feet per mile; so that each 1,000 tons of shipping could transport readily 10 miles of it, including its proportion of rolling stock in working order ready for use. Wedges are used to adapt the structure to inclines, which may vary, *ad libitum*, between the horizontal and 1 in 10, without a hole being bored or a saw cut required on the ground, or even the grade ascertained.[1]

The full size structure in the grounds of Fife House was tested to a curve of 80 feet radius. The grip-rails, which are in two pieces longitudinally, are bent in pairs by cramps *before bolting* them together, they consequently cannot return after bolting to the straight form when released from the cramps, since one piece cannot slide over the other by reason of the bolts. This sliding motion is, however, the effort which must be exerted before the length of each piece can be varied, and consequently the straight regained.

Since iron has many advocates, and proper timber is not always procurable; by reference to the drawings on the table, it will be seen how, even in this stubborn material, a portable railway can be laid over the roughest country on any grade or curve, without a stroke of smith's

[1] Lord Napier of Magdala has suggested an important modification, which has since been incorporated in the design, while the grip rail has been dispensed with. See page 22.

work being done *in situ*. The drawing almost explains itself; but attention should be perhaps directed to, 1st, the semi-circular saddle wedges on which the upper rail rests, and by the use of which the posts may always maintain the vertical when the rails are inclined. 2nd. The suspension chord-plate, which is shifted right or left on the head of the post, according as the curve is right or left. The plate, then, acts as a chord to maintain the curve.

The anchor footings also deserve notice, as in hard ground they are calculated to stand a side strain of 50 tons; although I do not myself consider the structure to have the least tendency to overturn, since all posts over 7 feet in height are tied provisionally, and strutted permanently with ladders. For crossing ravines and such like, skeleton piles of any required width of base may be used, since it is only the upper part of the structure *above the grip or guide rail* which must always preserve uniformity of section. Single girders, of any depth or span, may be used for a permanent structure, but lengths of 30 feet span are most convenient, as they will work in anywhere with the rest of the road.

The posts when of cast metal are made to one standard length, and are based with sockets which fit in the shoes, or into wrought-iron tube posts of various heights, suitable for bridge-work. Screw piles are also recommended, in certain cases. For a more or less rocky soil—as in Afghanistan—wrought iron trestle posts, resting on short wooden sleepers, are used. The posts are made of two J-shaped L irons, placed back to back, and so arranged as to work telescopically and fit sidelong ground and various elevations, without cutting. It cannot however be too distinctly understood that, as a rule, the rail level follows the surface of the ground as near as may be 3 feet above the soil, and that consequently no portion of it is out of the reach of a man.

The mode of erection is simple, and whether of wood or iron, the system employed is almost the same, the difference being that the wood footings should be buried, while the iron ones may be superficial.

After, by riding over the ground, the most desirable route (not necessarily the easiest) has been selected; No. 1 proceeds to mark out on the ground the precise line to be followed, in preference selecting soil of moderate hardness, as the most suitable. The curves are put in by eye or with fiddlesticks, and no particular attention need be given to long straights. With a facility of using grades of 1 in 10, sharp curves will seldom be called for, or bad (soft) ground rarely obligatory. The marking is performed by pinning down lengths of white tape, on which the 15-feet intervals for the posts are indicated by consecutive numbers.

No. 2 and staff proceed to range the grades by means of special graduated T-shaped ranging rods. The top of the T slides up and down, and is used to range the grades, and the scale shows the corresponding depth of hole required to obtain the grade indicated by the top of the T slide. There is one on the table. No. 2 also note the special requirements, if any, of any particular number, and indent for it accordingly. Thus, in positions where in civil cases the permanent way would be raised, or low overbridges constructed to permit of cross traffic; No. 2 squad will select suitable points (on straights) where gaps may be left in the permanent way sufficiently wide for the passage of artillery. (See Diagrams, sheet 5, Fig. 7.) No levels are

taken, but an inclinometer may be used when it is a question whether a grade exceeds the maximum.

No. 3 party, of about 100 men, dig the holes of the depth indicated on the numbered pegs driven by their predecessors, and collect stones to be used in packing and ramming around the posts.[1]

No. 4, or the erecting squads, arrive with the materials; they place the posts in the holes, and bolt up the rest of the structure. The posts are then ranged by eye as accurately as possible, being shifted right or left, or lifted and packed up a few inches, if necessary; the train may then proceed with the materials. No. 5 squads, after the train has passed, ram in stones and earth into the holes, punning carefully, and with but little stuff at a time. In hard soil, Tonite blasting charges may be used to make the holes; and, in soft soil, a conical-shaped monkey may be used to force the soil aside sufficiently to admit the posts, the ground being greatly hardened by the process.

One or more of the staff of No. 2 are daily sent back to the depôt with a list of the requirements of the special pegs, if any; and it is their duty to accompany the erecting squads, and to see that these special works are carried out, and not return to their staff until they can report execution. This is the only point where care is required, since the construction-train might, through carelessness, be delayed for the want of a mere trifle, especially if the road were in iron. No waggons are used in the construction of a *single* line, the materials being forwarded in bundles slung across light temporary wheels in the fashion of the timber lorries of this country, in which the load is self-supporting. Hence there are no return empties to impede progress. Stores may be transported in a similar manner in cases of a semi-cylindrical form, hinged in pairs to straddle the Pioneer, and roll easily when clasped together.

For the double line progress would be much more rapid, as the materials would be dropped by train piecemeal all along the route, and any amount of men could be employed in the erection; but in the former case, their number is limited by the rate of delivery of materials, which is, *pari passu*, with the rate of construction. The second line may be erected 7 feet from the first, roughly to gauge, so that the double road *may* be used as a gigantic single track, if required. The Sheet of Diagrams, Plate 5, Fig. 6, shows a 7-ton gun slung between two roads, and supported by a special truck whose wheels run on both the roads, while the engine and rest of the train keep to the single track.

The carrying capacity of the Pioneer is limited to 100 tons (gross) per train, on 1 in 10: and with 16 departures it could transport 1,000 tons[2] (nett) daily, which authorities state is more than enough for 100,000 men.

The crossing of tidal rivers may be performed on special posts, footed with ballast-sacks, such footings not being liable to scour, even

[1] The portion in Fife House grounds was erected by a scratch squad of Grenadiers, in the pouring rain, in four hours. To fit the structure to the ground, naturally something must be trimmed; and digging small holes is certainly simpler than cutting the posts.

[2] The tonnage of the oldest Indian railways is only 1440 tons daily.

in the Danube. The posts of landing jetties may also be so footed. Waters of unchanging level may be crossed with pontoons of the usual pattern, or made of freight boxes. By using self-acting syphons which automatically charge and discharge water ballast from the pontoons, the level of the floating bridge can be maintained unaffected by variations in a changing water level (See Diagrams, Fig. 5).

The machinery is guaranteed by the makers to take 100 tons over grades not exceeding 1 in 10 at an average speed of 10 miles an hour. The boiler can use salt water, and may burn wood, coal, or petroleum.

The novel features of the machine are: 1st, that the cylinders work differentially, *i.e.*, they always absorb a regular supply of steam, but automatically convert it into either speed or work according to the changes of gradient. Thus the locomotive, whether working slowly or quickly, always works up to its full power, the piston speed being invariably maintained at the maximum velocity—an effect which has hitherto been an unsolved problem in mechanics. 2nd, that its weight per axle is reduced to that of the freight axles, in this case 30 cwt., so that the road is built for the freight, and not for the engine. 3rd, that the boiler or steam generators are distinct from the grip or driving engines, and are not superposed, since no extraneous weight is required to obtain adhesion; the whole being attenuated and made as light as is strictly consistent with due strength in their parts. Thus any amount of steam power required can be obtained by applying extra boilers in the form of tenders, one engine being used in all cases. The weight of *one* pair of twin boilers does not exceed 4 tons=120 horse-power, which is sufficient for all practical purposes; but by merely adding extra boiler tenders, the same engine will work to 480 horse-power, without increasing the weight per wheel. 3rd. The vertical wheels are *not* driven by the machinery, since the gravity value of the engine is *nil* compared with its grip, hence needless complication is avoided, by the whole of the driving power in the engine and the break power of the vans, being solely exerted *horizontally* by the grip system. 4th. The horizontal wheels on one side of the train only, are strictly speaking driving wheels, *i.e.*, connected with the cylinders; their opponents are merely loose running counter-wheels. These latter alone are caused to advance and recede, to give the requisite grip. They alone compensate for wear and take the spring of the road, the driving machinery proper being perfectly rigid and springless, and its mathematically exact action is thus never interfered with in the least, even on the roughest road. Such an engine will last for months without repair, its parts being as free from the effects of rough movement as though it were a stationary engine. (See Plate 4.)

The horizontal driving machinery is in duplicate, one in each tender; and each engine proper, that is to say, pair of cylinders and two driving-wheels, is in one piece. Each weighs three-quarters of a ton, and are detachable whole from the tenders of which they form a part, I having found from experience that it is very undesirable to place the motion within the dilatation range of the boiler shell.

5th. The power of the grip is so enormous that, even under full pressure, the train could be stopped without cutting off steam; it con-

sequently becomes necessary, on an ever-varying surface-line, *to control the grip* so that its action shall meet, but never exceed, the gravity requirements of the train. By means of levers, in connection with the draw-bar which attaches the engine to the train, the ever-varying strain on the draw-bar is communicated to the horizontal wheels, and the grip varied accordingly: thus—

On ascents, the grip is increased and the steam power augmented; while, on descents, the grip is used as a brake and the steam turned off, in proportion to either the pull or thrust on the draw-bar. Thus, every minute change of grade is, so to speak, *felt* by the engine, and its gripping effects automatically varied accordingly. Speed on descents is thus perfectly safe, for a hill and dale line could not be worked without a governor of some kind.

6th. The horizontal boilers are longitudinally divided by tube plates into water sections of about three feet each, a smoke box between each section. Thus, the water-level difficulty on inclines is removed, and the evaporative power of the boiler greatly increased, the gases leaving the chimney at a comparatively low temperature (Lawrence's Patent).

The engine is provided with a water balance, by which the driver can correct the equilibrium of the train when rendered necessary by very unequal loading.

The three general views are merely sketches taken from the *Graphic*; the working drawings, for obvious reasons, are not published.

Now mechanics know very well the value of working from a centre; nothing can even be delineated, much less worked, without its use. From the sidereal system down to the central fire breech-loader its value is indisputable. Hence, we must not consider as at all outrageous the proposition of running on one rail, or feel surprise at the numerous mechanical advantages its use presents.

By its use smooth running will be assured, for both the effort is exerted, and the resistance offered, in the axis of the train; and consequently in the same plane: while the centre of gravity is positively below the level of the running surface, thus yielding the perfection of stability. The V-shaped running wheels centre themselves on the apex of the rail, and there is consequently always a perfect fit and no lateral play, as on an ordinary railway. Derailment is also impossible should the structure sink even a foot; while with two rails, let but one sink imperceptibly an inch, and derailment would be certain, and the narrower the gauge the greater the risk. The same objection is applicable, but with greater force, to the Aldershot trestles, especially on side-long ground. Moreover, the two rails of a railway never can be laid or maintained alike; on curves one rail is always longer than the other, and one wheel consequently endeavouring to outstrip the other to a degree sufficient to force powerful engine-frames considerably out of square; while every shock on the one rail is bandied backwards and forwards to the other with destructive results, computed at over 70 per cent. of the total wear and tear. The train on one rail, however, will perform long sailing like lateral undulations, but oscillation and hammering cannot possibly exist; for their causes, viz., a wide base (or

rather two rails) and a high centre of gravity are absent. A wide base is quite correct for statics, but singularly out of place in moving bodies, the perfection of form of which is a sphere.

It may have been noticed what a violent wrench is given to an omnibus when one wheel runs on the smooth tram-rail while the other is unduly retarded by the macadamised road alongside; the vehicle strikes out a considerable S curve which the horses must find very unpleasant. On riding in front, the movement of the pole can be noted, even on an ordinary road; it is most extraordinary, jumping about a foot or so from right to left according as the one side or other is the most retarded by friction, which never can be alike under both wheels, whose diameters also are rarely the same.

From a military point of view, the importance of abolition of weight in the engine cannot be over-rated. It means not only rendering the engine itself handy and light, but every portion of the temporary structure also.

I think I need scarcely apologise for mentioning these details, because unless they are fully studied and met, my experience of unhopeful countries suggests, that animal transport[1] used mechanically, would be a much more reliable source of power for military purposes than steam; besides being far easier to organize.

In such cases the Pioneer would be used with a tow-rope, the animals choosing the best ground they could find, say within a few yards of the structure: while the structure itself might be roughly knocked up of any suitable local materials, since the girders really bear no weight, and do not require careful workmanship or any nicety in the arrangement of the joints. The merits of such a tramway are that, unlike tramways in general or roads, full advantage can be taken of all descending gradients to work them by gravitation; while the rail offers less resistance to mounting inclines than even the best carriage road, a luxury mules and pack animals don't appreciate, and which is moreover quite out of the question; since road construction can neither be hurried to suit military requirements, nor properly kept in repair under the abnormal wear. Rivers, ravines, and spots unpromising for horse traction, would likewise be worked by natural or artificially obtained gravitation. Even such a tramway would be invaluable; since its constitution being unaffected by the elements, due to the elevated rail: regularity of supply could be maintained in all weathers. The ascents only would be worked by animals arranged on the stage system.

No waggons are used, the cases themselves being attached to a yoke and wheel on a system analogous to the timber lorries of this country; hence for a rapid military expedition there would be no return empties and no necessity for either a double line or turn-outs. These cases possess sufficient flotation for floating ashore when discharged over a ship's side. The construction materials are also tied up into self-supporting bundles fitted with temporary wheels; so that the laying of the road is continuously forward.

[1] The Pack system is ruinous, because the poor animals never get a rest, even during the long weary hours waiting about in camp preparatory to a start, &c.

For local purposes, forming camps, fortifications, &c., where a moveable tramway is required; I should imitate the wheelbarrow and plank on a large scale, and use the one-rail tramway shown in Plate 2. It can work either by men or horses, will enjoy easy traction, and can ford a stream by the assistance of the pontoon collar. It can also pick its way even on sidelong natural ground—one wheel always finding its own transverse level.[1]

The Pioneer train is a continuous metal skeleton formed of waggons of one type, which can be used either for troops and their baggage, or for stores only; merely by turning up the seats. (See Plate 3, page 7.) Each double carriage can carry either sixteen men and four boxes of 40 cubic feet each, or four boxes of 240 feet aggregate; and in addition, bulk to the extent of two bundles 7 feet by 6 feet by 4 feet (say hay). In iron they weigh nearly 2 tons each double waggon, but the constructors hope by the use of steel to reduce their weight nearly one-half.

They are formed into trains of about 30 waggons each, and are never detached except for repairs.

They are coupled at the *roof* level by means of flexible or rather hinge-like joints, *f*, which admit of no lateral play. Thus, although the train is articulated, the natural tendency to overbalance of each individual waggon is restrained by its neighbours fore and aft; and consequently the average load of one side of the train is available as compensation for the average load of the other: and hence unequal loading of units has no palpable effect, and we shall not be required, as in pack-loading, to add on huge stones to maintain equilibrium.

With reference to steam sappers for use on common roads very little need be said. His Highness Mithad Pacha tried them in Mesopotamia; their action as road rollers may be beneficial, but that is not quite what is wanted. Their broad wheels won't work on a sharp cambred military road; their weight is destructive to bridges; they want endless supplies of water; and even in Paris, where roads are good, they have not proved a success.

They would be quite out of place in many countries where no roads of any kind exist, like Syria and many parts of Asia Minor;[2] while on the Danube the impalpable alluvial soil does not afford even the minutest quantity of any road concreting materials; while even had we facilities for road making, the chronic state of repairing of Whitehall would prove beyond doubt that macadamised roads won't stand heavy traffic, more especially in countries where the rainy and dry seasons are distinctly marked. Road making and maintenance I have found a most difficult operation, the more so as even Turks think it is so simple a matter as to be left to itself.

Few persons, even engineers, have learnt the all-important lesson in road making, that the foundation and the surface are two totally distinct elements. That mother earth affords the best possible foundation if left as time and nature has consolidated her; but affords the most treacherous of surface material for resisting wear and weather.

[1] Captain Geddes suggests the use of such a cart for transporting entrenching tools and spare ammunition—say one to a company.

[2] The missionaries have ordered one for Africa. I shall be curious to learn the result.

Such a simple structure as the Pioneer could be certainly managed from beginning to end by a military organization, which renders its members more fit for working in large numbers with expedition than civilians, who perhaps *per se* may be more expert in this special branch. I know I found it so with Turkish soldiers, even although at first I did not speak their language.

What we want is not individual cleverness, but the general education which army organization, like society, affords: viz., of knowing to a certainty what is the right thing to do under all circumstances.

With the aid of a Naval repairing ship, Pioneer steam field lines could be laid and worked at the rate of five miles a-day, counting from the date of arrival at a port.

I may mention that this form of railway was designed for the Ottoman Empire, to eradicate the famines which are chronic there, and more or less so in all vast continents; and a model line of 100 miles or so of this kind of railway would I think afford a more suitable present than any amount of money squandered away in famine works.[1]

As a military weapon, too, such a steam road is a necessity in waging war against semi-civilized peoples, since the bare conquest of their homes does not carry with it their owners' subjugation, as in Europe; and therefore some permanent force of some sort becomes a necessity concomitant of victory: and what better could be found than a military railway, which renders the blow more sure and rapid, yet makes up for the ravages of war by introducing wealth and commerce almost simultaneously with much unavoidable ruin.

A glance at Stanford's map of the Dardanelles and Bosphorus shows that, as suggested by Admiral Hobart Pasha, two short lines of railway might be of infinite service in the event of these two guts being stopped.

One within the lines of Boulair of about 10 miles long, from the Gulf of Saros to the Sea of Marmora, to turn the Dardanelles; and one from the Gulf of Ismid to the Black Sea, about 30 miles, should the Bosphorus be closed. The Boulair line is rough, the cliffs being precipitous, and only accessible by steep ravines; the highest point is about 800 feet.

On the Ismid line the summit is over 1,600 feet, and the line over the pass from end to end would average about 1 in 15; so that in both cases a railway proper would be a very tedious operation, and even the surveys require some months: while the carrying powers would be almost *nil* and the line very circuitous.

Although in this paper I advocate a modification of the grip system as the best gravity traction antidote, I do so at the present critical moment merely because it has stood the proof of mechanical experience, and all its weak points are known, and it can therefore be relied upon for the present emergency. It was first patented by a

[1] In a letter on Indian Famines, in the *Times* of July 5th, and signed Robert H. Elliot, the evil of employing men on earthworks as famine relief is as true as it is wasteful.

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Mr. Eyre in 1843, but was worked out, essentially as employed on the Mont Cenis, by Mr. Vignoles and Captain John Ericsson in the year 1830.

We must not, however, forget that the grip-rail, even if arranged to do duty as a guide as well, is a source of considerable weight and expense: and, though properly understood, the grip system is certainly master of any grade; yet it is at best but a substitution of concentrated *effort* for concentrated weight.

To avoid the use of concentration in any form, which cannot be economical in the long run; I have all but perfected a system of continuous driving, which is merely the antithesis of continuous braking,[1] wherein the effort is distributed to the extreme since every wheel is a motive one, and no opposing load has to be dragged. Hence grades of 1 in 7 can be surmounted with trains of any desired weight, commensurate with the *maximum* power which it is possible to produce in the generators.[2] The differential machinery is the same as for the grip system described upon page 16. (See drawings on the table).

A road for the same would be simply the perfection of economy; 1, because the weight of the whole train is homogeneous; and 2, because the tractive effort is spread over the whole length of the train, and concentration of both weight and wear on the rails and spans is skilfully avoided. The weight of such a road would not exceed 40 tons per mile complete.

For military motors, in conjunction with this continuous system, I should advise the use of the Herreschoff torpedo launch boiler; since 20 horse-power only weighs 15 cwt.,[3] a magnificent result of securing the force of twenty horses in the weight of one, which is not utilisable for machines of the "weight is power" principle; and would in the ordinary way be utterly useless for locomotive purposes, for which its special virtues, however, so admirably suit it. The fact is, that public opinion, which has a powerful voice even in engineering questions, is amply satisfied, provided whatever is suggested has either been done before, or will at any rate make believe to work by performing next to nothing, smoothly, and without a hitch; quite forgetting that the most specious machines, like individuals, are those who manage to get on with the least amount of principle.

I will now conclude with the hope that members joining the discussion will not generalise, but endeavour to give examples within their own experience of any fact which may controvert the common sense principles upon which the Pioneer has been designed.

[1] Captain Douglas Galton by a course of most exhaustive experiments has proved the soundness of these views (see "Nature," August, 1879).

[2] Now with respect to gradient—Mr. Haddan's system contemplates connecting the whole of the wheels of the train by means of an endless rope; theoretically therefore he could work gradients from 1 in 4 to 1 in 6, say in practice 1 in 10. With such a gradient he could go anywhere, and by the facility the rope also affords of applying continuous brake power, he could descend that gradient successfully and safely. The same end may also be attained by transmitting the motive power to each wheel, by hydraulic machinery, vacuum, compressed air, electricity, &c.—*Extract from Mr. Grover's Report.*

[3] This maker has now produced a 4 horse-power marine engine, boiler, screw, and all, which only weighs 50 lbs.

Axioms on which the Construction of the Pioneer is Based.

(1.) The Pioneer, or steam caravan; supplies a means of communication whereby an exceptional economy, both in construction and working, will be attained: by a perfect subservience of technical means to commercial wants.

(1*a*.) All public works in uncivilised countries should be mutable, there not being sufficient reliable data to work upon.

(2.) The raising of capital for the Pioneer to any amount, is feasible, since all the materials used possess an intrinsic value; moreover, the outlay is, at the same time, precisely proportionate to the nature and amount of the existing traffic. About 25 per cent. only would therefore form the capital, the remaining three-quarters being raised by debentures.

(3.) The construction entirely depends upon foreign or workshop labour, so that the speed of production is unlimited and cheapness insured by competition. Workshop labour is work executed in the cheapest form, and its organization is perfect. Navvy labour in deserted countries is the reverse.

(4.) Earthworks, consequent on their great first cost in hand labour, disturb the labour market. In addition, their slowness of achievement renders such works quite unsuited to the regeneration of bankrupt, underpopulated, agricultural states, (such as Turkey).

(5.) In an agricultural empire, given a certain sum to expend on railways, the expenditure, even if at a sacrifice of perfection, should be diluted to the fullest extent, so as to operate over as large an area as possible.

(6.) In an agricultural empire, a return for capital expended in the soil is immediate, and greater than from any mercantile or manufacturing pursuit, while the time required for development is the shortest possible.[1]

(7.) A fixed transport tariff is a *sine quâ non*; free trade in inland transport rates is prohibitive of all large operations, especially with bulky agricultural produce.

(8.) Any luxury, either in the station or general accommodation, is quite uncalled for; the minimum of comfort consequent on the lowest possible tariff is what undeveloped countries require, and can only afford.

(9.) The population should not be spoilt by the introduction of inordinate passenger speed and rapid goods delivery—both costly items. Even the minimum percentage of amelioration over existing transit speed, would be a mistake.

(10.) The tariff fixes the distance from which it will pay to transport produce. Therefore, the lower the tariff the greater the area each mile of rail will bring under cultivation; a high rate of inland freight is in favour of the importer of foreign goods, while a low rate encourages exports.

(11.) If a railway on an important line be constructed on so expensive a plan as to require a high rate of charge to enable it to pay a good dividend, irreparable evil will have been done, and the whole powers of an influential body—influential and powerful just in proportion to the amount of capital expended—will be brought to bear on that line; *not* in order to secure cheap transit, but to prevent cheap transit on it.

(12.) Speed over rough country is only attainable by light, attenuated trains.

(13.) The holders of cheap means of communication, if secured by monopoly, are masters of the commerce of the country in question.

(14.) Elasticity in the choice of route renders local land "rings" harmless.

(15.) Rapidity of construction means economy in its broadest sense.

(16.) A cheap system, unless its working expenses are proportionate, is not an economical one.

(17.) In an agricultural State the general rules to be observed in setting out its railways should be the reverse of those usually applied to manufacturing countries; for manufactures have fixed centres which have taken centuries to grow, while cultivation is ubiquitous, and reaches perfection in a season. The one the railway must

[1] This discourages the investment of local capital in railways, since earthwork in roads and railways is the worst possible form of labour investment, and judging from Indian statistics would never pay. India has spent since 1860 over 114,000,000*l*. in railways, and the return has not yielded 1 per cent. all round.

go to, the other can follow it. Manufactures represent immense wealth crowded into small areas, and require so be met by trains of enormous carrying powers: the greater part of the traffic being through traffic. Agriculture, on the other hand, represents considerable wealth spread over an enormous area, and requires to be met by great length of line with numerous trains of but moderate carrying capacity, the greater part of the traffic being picked up by the way side.

(18.) Main lines should run as direct as possible, and on no account make detours to tap existing agricultural riches. For cultivated lands, having already a market (or they would not exist), do not require a second outlet, at least till other less favoured districts are supplied. Later on, these prosperous districts, ignored by the main line, will clamour for branches, while an uncultivated neighbourhood would never demand railway extension of any kind.

(19.) The perfection of land steam-transport is attained when concentrated weight does not constitute tractive power, and when consequently the strain is equally distributed throughout the whole train.

(20.) The perfection of economy in construction is attained, when the running load is of equal weight throughout.

(21.) The perfection of economy in wear and tear is attained by concentrating the damage done into the rolling stock, instead of allowing the same to be diffused over the whole line. It is effected by purposely constructing the permanent way of much harder and more durable materials than the rolling stock; and by throwing all the strains upon the latter.

(22.) The perfection of safety is attained when passenger or quick trains are divided from goods or slow trains, by the appropriation of distinct lines to each class of traffic; and when the centre of gravity is below the level of the rails.

(23.) The theoretical capacity for a waggon is one unit of the merchandize to be carried. Concentration should be avoided.

(24.) The capacity proper for a waggon is quite independent of the amount of traffic. More frequent trains, and not larger carriages, are required to meet with economy any increase of traffic. For light frequent trains utilize the capital expended in the road to its utmost, at a minimum of wear and tear; while heavy occasional trains let the line lie idle the greater part of the twenty-four hours, and then knock the road to pieces.

(25.) When weight constitutes power, reduction of gauge does not produce a proportionate reduction of weight in the locomotive. On the contrary, the disparity of weight between the locomotive and carriage is still further exaggerated thereby; consequently railways in miniature cannot be constructed, since the point is soon reached wherein the locomotive cannot do more than pull itself, especially if the inclines are at all steep.

(26.) A single-line narrow gauge railway requires on an average a width of at least 20 feet of soil to be prepared for its reception, while the smooth running surface, secured at so much expense, only equals the width of the two iron rails, viz., 5 inches. The same anomaly, still further exaggerated, prevails in a carriage road whose whole surface has to be kept in repair because the carriage wheels can wander laterally *ad libitum*.

(27.) On a wide gauge the dead weight increases, on a narrower one the capacity diminishes (Fairlie).

(28.) Every ton of dead weight saved goes toward securing the prosperity of the line (Fairlie).

(29.) One and the same rail cannot suit both the locomotive wheels and those of the train, nor can a grip engine and a gravity one assimilate, as was attempted on Mont Cenis.

(30.) Great economy in construction may be obtained by spreading out the load to be carried, thereby reducing the weight to be borne per yard by the rails, bridges, &c., greatly diminishing the first cost without reducing the carrying capacity of the line.

(31.) A weak double line is infinitely superior and cheaper than a strong single one.

(32.) Running on one rail is preferable to two, the perfection of form of any moving body for insuring steadiness being the sphere.

(33.) A system which disturbs neither nature, property, nor the labour market, avoids three of the most expensive items of railway construction.

(34.) Though necessity is the mother of invention all the world over, yet Turkey and England are not akin, and should not be expected to treat their offspring to the same porridge.

TABLE No. I.—*French Railways.*

Report on the percentages of Waggon Rolling Stock in circulation, and out of circulation at any one time, averaged during seven years. Stock in repair not included.

Name of Company.	Mean speeds.	Percentage in circulation, including stoppages at stations.	Percentage out of circulation.
	Miles per hour.		
Nord	17·1	6	94
Est	10	12 9/10	87 1/10
Ouest	10·7	11 8/10	88 2/10
Orleans	16	10	90
Paris and Lyons	9·7	13 4/10	86 6/10
Midi	11·4	9	91
Mean	12½	10½	89½

TABLE No. II.

Comparison of effects obtained by the use of a Locomotive, which acts on the principles that "Weight is Power": with a Pioneer engine of equal weight, viz., 8 *tons.*

Inclines.	Horse-power.	Weight-power Engine.		Pioneer Engine.	
Rate of inclines assumed in calculations.	Amount of h.-p. required to move 100 tons gross load at 8 miles an hour.	Weight of train including engine and tender.	Actual h.-p. required for foregoing weights.	Weight of train including engine and tender.	Actual boiler power required for a 100 ton train.
		Tons.		Tons.	Weight h.-p. of boiler.
1 in. 10..	480.....	 8.....	 *40*.....	100....	*480*=8 tons.
1 „ 20..	240.....	 16.....	 40.....	100....	240=4 tons.
1 „ 40..	120.....	 32.....	 40.....	100....	120=3 tons.
1 „ 120..	 40.....	100.....	 40		40=2 tons.
		Here 40 h.-p. is all the steam-power which an 8-ton gravity engine can assimilate.		Here the Pioneer assimilates the whole of the h.-p. supplied, viz., 480 h.-p.	

Table No. III.

Comparison of amounts of Dead Weight, and paying load in the two systems.

Incline.	Weight-power Engine.			Pioneer Engine.		
	Proportion of dead weight to paying load in a 100 ton train.			Proportion of dead weight to paying load in a 100 ton train.		
Rate of incline assumed in calculations.	Engine.	Brakes and waggon	Paying load.	Engine and boilers.	Brakes and waggons.	Paying load.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1 in 10	100	Nil.	Nil.	8	32	60
1 „ 20	50	16	34	4	32	64
1 „ 40	25	25	50	2	32	66
1 „ 200	8	32	60	1	32	67

This table shows that grip on 1 in 10, is equal to adhesion by weight on 1 in 200, = 240 fold.

Table No. IV.

Abstract Value of various types of Railway Construction over the same line of country.

	Gives or		Gives or
1. Heavy earthworks[1].... 1st class railways.	= Good grades and tolerably direct route.		= Light rails and rolling stock, and good paying load.
2. Inadequate earthworks Light cheap (?) railways.	= Bad grades and circuitous route.		= Heavy rolling stock, and serious amount of dead weight.
3 No earthworks..... Steam tramways on country roads.	= Very bad grades, which cannot be modified.		= Extravagance in power, and minimum of equivalent load.
4. Fell's system[2] Earth cuttings, but timber viaducts in lieu of banks.	= Very lofty viaducts, bad grades, and circuitous route.		= Unremunerative load, since being ariel must be used with exceptionally light rolling stock.

[1] George Stephenson, its inventor, fixed the limit of traction by gravity as 1 in 300; to obtain which an unreducible quantity of earthwork is obligatory: but if to get rid of this expense we cut down the earthworks and use steeper grades, then we must seek, as in the Pioneer, some other motor than concentrated gravity. With the Pioneer, however, where *all* the wheels are coupled, the economical maximum grade is 1 in 7. So *it* can always command a choice of route, which no other system of railway possibly can do.

[2] At Aldershot Mr. Fell's locomotive could only take a nett load of 14 tons up

5. Pioneer..... No earthworks.	= Surface line, *i.e.*, very bad grades over rough country. Route as the crow flies.	= Light rails and rolling stock, but good paying load. (Compare with No. 1.)

THE EUPHRATES VALLEY RAILWAY.

The Pioneer, which supplies the missing link between the railway proper and the telegraph, was specially designed for this strategic route, which, being at the present moment a question of military interest, the following addenda has been supplied by the author.

As an *avant courier* of this great enterprise, the Pioneer would be constructed entirely of iron (see estimate). The fixing thereof requires but eight simple operations per 24 feet, viz., sinking or screwing two short piles into the ground, and fixing six bolts; so that with only 200 trained men (soldiers would do), a daily advance from each point of departure, of two miles, could be constantly maintained.

In proportion as the main line overtakes the Pioneer, the latter is at once broken up into branches to feed the former and render it fully profitable at the earliest possible moment; thus providing branches at a nominal cost. By this means the Euphrates Valley Railway might be an established provisional fact within a twelvemonth from the driving of the first Pioneer pile, and almost immediately earn the proposed mail subvention of 300,000*l.* annually; which sum, pending the completion of the main line (say ten years), would be more than sufficient to repay the outlay required of 1,000,000*l.*, plus good interest for the use of the capital, to say nothing of its future value in branches after it has assisted also the construction of the main line by acting as contractor's plant. A very trifling capital would suffice for the first start from the Mediterranean to Aleppo (see estimate). The Porte has offered to give a belt of land gratis, so that nothing but Russian influence stands in the way of its execution.

The special requirements called for by the peculiar conditions inherent to the Euphrates Valley route are met by the Pioneer, and by no other system of railway construction. The conditions to be met are the following:—(1.) A mechanical means of economising manual and animal labour *in situ*, by performing nearly the whole of the work in Europe, leaving next to nothing to be done locally.[1] (2.) Great rapidity of execution, so as to reduce the interest on capital during construction. (3.) The establishment of branches simultaneously with the main artery, without undue cost. (4.) Through communication of small capacity as rapidly effected as possible.

Model Estimate.

TO ALEPPO, *viâ* AYAS AND KILIS.—LENGTH 104 MILES.

Transport capacity—400 *tons daily in each direction.*

104 miles of viaduct, in iron, at 960*l.* per mile	£100,000
Erection and freight of same.....	30,000
10 locomotives at 800*l.*	8,000
320 carriages and waggons at 25*l.*.....	8,000
Incidental expenses	4,000
	£150,000

1 in 50, although the grades were improved to the utmost by a 5-foot cutting and a 20-foot viaduct. He admits that his system is, as regards grades, 50 per cent. worse than one on the ground, so *cui bono?*

[1] Mr. Skene, the late Consul of Aleppo, in his evidence on the Euphrates Valley Railway, dilates upon the danger of drawing men from the plough, and consequently revenue from the State; and with reason: for the construction of the railway would abstract no less than 30,000,000 days' work from the soil, which cannot be spared, since the existing agricultural labour supply was only $\frac{1}{7}$th the lowest computed requirements of the province, which war and famine have still further aggravated.

The land is provided gratis by the Porte, and stations, if required, will be built by the communes.

The existing freights between the city of Aleppo and the port of Alexandretta, on the Mediterranean, averages 50 tons daily, of a value of 60,000*l.* annually, paid to camel and mule drivers (see Consular reports), without reckoning the commerce of Kilis, which is at least one-third more. In 1873 the amount rose to 85,000*l.*

Taking the lower average of 60,000*l.*, and deducting 50 per cent. for working expenses, there remains 30,000*l.* as annual profit on an outlay of 150,000*l.*; in other words, 20 per cent. return from traffic already existing. Of this sum the subscribed capital need not exceed 40,000*l.*, the remainder being raised by debentures.

Table of Quantities.

FIRST CLASS IRON VIADUCT[1] (CONTINUOUS DRIVING).

	Tons.
440 iron posts, at 168 lb. (including shoes, &c.)	30
1,760 yards top rail, at 20 lb. per yard	16
3,520 yards guide rails, including bolts, &c.	20
Total	66
	Per mile.
Which, taken all round at 12*l.* per ton, f.o.b. at Liverpool, equals	£800

TIMBER VIADUCT (GRIP).

	cub. ft.
440 posts, 8 inches square by 7 feet long, including wedges	1,400
5,250 feet run of sawn planking for vertical rails, 8 inches by 4 inches	1,170
800 struts, dressed on two sides, 4 inches by 4 inches, by 2 feet 4 inches	210
5,250 feet run of hard wood grip rails, 4 inches by 12 inches	1,750
Total cubic contents per mile	4,530
Which, taken all round at 2*s.* 6*d.* per cubic foot equals	£560
Ironwork rail, 15 lb. per yard, including screws and spikes, = 15 tons at 15*l.* per ton	225
Total per mile	£785

THE PIONEER.

General Detailed Estimate.

Viaduct, when in iron, per mile	£800
Viaduct, wooden posts, and iron rails, horse traction (Tramway)	400
Freight at 30*s.* per ton, Liverpool to Alexandretta	120
Viaduct, when in wood, without iron rail (grip system)	560
Viaduct, when in wood, with iron rail do.	785
Average cost per mile, excavating and filling in holes, 400 holes at 2*s.* 6*d.*	50
Average cost per mile, rolling stock	200
Cost per mile, erection in wood, 200 men at 5*s.*	50
Cost per mile, erection in iron, 100 men at 10*s.*	50
Cost per mile of staff, &c., say	40

For further particulars apply to Herbert and Co., 67, Strand, Sole Agents.

[1] The Landore Siemens Steel Company are endeavouring, by the use of their celebrated steel, to bring the weight down to 40 tons per mile.

Discussion.

Mr. Fell: Sir Garnet Wolseley and gentlemen: I am sure it is the feeling of this meeting, and also of the public outside, that Mr. Haddan has done good public service in calling attention to this very important subject of military railways, especially at the present moment. Mr. Haddan has made some remarks on an experimental line that I carried out at Aldershot, to which I should like to reply; but, before doing so, I wish to say I agree with Mr. Haddan, and I believe almost everybody who thinks on the subject must agree entirely with Mr. Haddan that, for military purposes, earthworks ought to be superseded by a structure of some kind—it may be of wood, or of iron—it may be one rail, two rails, or three rails—but it must be structure of some kind. Earthworks cannot be executed, that is, if they exceed four or six feet in height or depth, within the time required for military purposes, and, when executed, they would be so liable to get out of order; their subsidence would be so frequent, from rains and other causes, that a railway made with earthworks exceeding six feet in depth, would be for a long time practically useless; indeed, the railways constructed during the Franco-German War round Metz, with the labour of 4,000 men, in about a month, was worked for about thirty days only, and during that time was found to be almost useless. The question under consideration is that, if a railway has to be made with great rapidity, and required to be used immediately it is made, what kind of structure is best for the purpose? Mr. Haddan has attempted to demonstrate that a single rail is best. Now, I have come to the conclusion, from seven years' experience, that a structure with a single rail is the worst that can be used. I have tried both, and I have found two rails answer very much better than the one rail. I began by making experiments in the north of England with a single rail railway. Captain (now Sir Henry) Tyler did me the favour to look at it, and also to look at a very narrow gauge railway erected near Barrow-in-Furness, with an 8-inch gauge; the 8-inch gauge railway worked very much better than a single rail. When I made proposals to the War Office to put up an experimental line at Aldershot, I increased the 8-inch gauge to 18, and the 18-inch gauge worked better than the 8. I have now come to the conclusion that it would be better to have, at least, a 2 feet 6 inch or 3 feet gauge, and I believe a 3-feet gauge railway will work better than an 18-inch gauge, and better than a single rail. One considerable objection to a single rail, or to any very narrow gauge, brought to my notice by the Royal Engineers' Committee, was that it would require a special kind of rolling-stock. You have all your rolling-stock to make when required for use, unless it is kept in store, and no Government likes to go to the expense of keeping many miles of a particular kind of railway in store for, is may be, use within five or ten years, and the War Department made this objection to the 18-inch gauge, and that was one reason why, in the plans which I afterwards prepared, I proposed to use a 3 feet gauge. Another reason is this, that by using a 3-feet gauge you may altogether dispense with the guide wheels. If you have guide wheels when the line is on the surface, you must necessarily raise your structure a considerable height above the ground, being so much labour thrown away, and so much carpentry work to keep in order, which is entirely unnecessary. Mr. Haddan has claimed for his particular form of one rail railway great economy in construction. Now, the structure has to be made of sufficient strength to carry the weight of the engine and waggons, and whether you put the whole of that strength into one or two posts I cannot see that it affects the supporting power; but if you put it into two posts, and connect those posts together, while you have the same bearing power, you have very considerable lateral strength, which you do not get when the vertical support is all put into one centre post, without any lateral struts to steady it. Therefore, at Aldershot, I adopted a form of this kind: first of all, there was the centre post and then two lateral posts; afterwards, I dispensed with the lateral posts, and had the two outside posts only on a very light post in the middle, merely to bind the whole structure together. I think it would be a very considerable advantage, in any military railway where a structure is used, to be able to use it in connection with an ordinary surface line. I think when the country permits of a line being laid on the surface with a gauge of 3 feet, or a metre, which will be sufficient for this purpose, the ordinary cross-sleeper form of permanent way is the very best that can

be used, and has great advantages to the single rail system proposed by Mr. Haddan. A railway of this kind, or of the kind we had at Aldershot, forms a barrier across the whole length of the country through which it passes. If you want a level crossing, you must make a movable bridge over the railway, or you must make a portion of the railway to open. I imagine, from that drawing, where the line is on the surface, the structure is 3 feet above the level of the ground, and, in that case, how are you to cross it? You may want level crossings very frequently, in some countries. At Aldershot, we found considerable inconvenience from this cause. You cannot use the ordinary points and crossings, which is a great disadvantage. Therefore, if you can use the ordinary surface line along with the structure, you gain the advantage of the structure for going over uneven ground, and the advantage, also, of being able to use the simplest and best form of railway where no structure is required. Mr. Haddan observed that, at Aldershot, we put in a viaduct of unnecessary height. As he has shown, by that diagram, there is a viaduct, to cross a valley, of 25 feet in height. That is true, but Mr. Haddan was not quite aware of the circumstances under which the line was made. It was purely as an experimental line, and not as selecting the best line of country, and that viaduct was put in on purpose that we might have a viaduct, and that we might find out what would be the action of a train running at a high speed and with a load 25 feet above the level of the ground. It was put in exactly for that, and no other purpose. What I should propose at the present time would be, in such a case, to make a slight cutting. He has shown a 10 feet cutting and a 10 feet embankment. That, of course, is an exaggerated section. You would not find a country like it. There would be longer cuttings and longer embankments than those. Instead of filling up the whole 20 feet, I should propose making a cutting of 2, 3, or 5 feet, and fill up the rest with a structure. In that way you might execute just as much earthworks, and use just as much structure, as circumstances rendered desirable. Then, with regard to rapidity of execution, I do not know whether Mr. Haddan has made experiments, for any length of time, with that form of structure, in order to prove what length could be put up, with a certain number of men in a certain time, but at Aldershot we worked away from March to June, 1873, in order to ascertain, for a structure of that kind, what number of men would be required to execute a mile in a day. The programme agreed upon was that we should be able to make one mile a day with 500 men over similar country to that at Aldershot, and using military labour alone; a few sappers were used, but the rest were men of the line. One half of the railway was taken down and re-erected. Each set of men had about a week's practice, and when the Royal Engineers' Committee came down to see the experiment, we were working at the rate of two miles a day with 500 men, so that we performed double the amount of work required by the programme. I think Mr. Haddan used the word "failure" in connection with the railway at Aldershot. I have with me a copy of the Royal Engineer Committee's report, given me by the Secretary of State for War, in which he does not call it a failure, but in which he certifies that the whole of the programme, both as regards the loads to be carried, duty to be performed by the engine, as regards speed and so on, and also as regards the power of constructing the railway with great rapidity, has been satisfactorily fulfilled, and, therefore, I think it would be doing me an injustice if it were to go abroad to this meeting and the public that the work I undertook to do at Aldershot was a failure. I can show any gentleman, who chooses to take the trouble to look at it, the report in which it is stated that, instead of it being a failure, all the conditions of the programme were satisfactorily fulfilled. Allow me to make one other remark on the subject of non-gravitation traction, that is, traction by horizontal wheels. My friend, Mr. Brunlees, here and I have had a great many years' experience of that method of obtaining tractic power, perhaps, more than most other people, on the Mont Cenis, where the trains were taken over principally by traction of this kind. The adhesion that could be obtained from gravity was not sufficient to overcome the gradients, and the engines were each supplied with two pair of horizontal wheels. I think Mr. Haddan stated that such an engine as he proposes would take 100 tons, at 10 miles an hour, up a gradient of 1 in 10. I can only tell Mr. Haddan, upon the Mont Cenis, with an engine of 20 tons weight, the utmost we could take up 1 in 12, at 6 miles an hour, was 50 per cent. more than the weight of the engine, that is, 30 tons in addi-

tion to its own weight. Consequently, he would require, in order to perform the work he proposes, an engine of 100 tons weight to take a load of 100 tons up a gradient of 1 in 10, at a speed of 10 miles an hour. These engines of the Mont Cenis were made particularly with regard to economy of weight; the boilers were made all of steel plates, and the frames of steel. All the working parts were made of steel, and every pound weight that could be saved was saved, and that was the result. Therefore, looking to the experience we had on the Mont Cenis, I must entirely disagree with Mr. Haddan in the statement he makes that it is possible for an engine, of the description he proposes, to take 100 tons up a gradient of 1 in 10, at a speed of 10 miles an hour. Then, with regard to the plan he proposes of having driving wheels on one side only, we had, on Mont Cenis, three or four engines in that way, and they were an entire failure. I think he will find it is necessary to have spring pressure on both sides, and to drive the wheels on both sides, or he will not be able to get the full effective work out of the engine. I understood Mr. Haddan to say, in some countries in which a railway of this kind might be used, you might go a long way without seeing a stone. Now, according to the diagram, his post is fixed in with stones, or some hard material, consequently, that plan could only be applicable in a country where stones could be had, for he would never carry all the stones with him to make a railway of this kind. Would not it be much better to have a sleeper which can be laid on the surface, and would not require work of the sort? I should like to know what kind of a structure he would employ where it was necessary to rise up 20, 30, or 40 feet above the level of the ground, for instance, for passing over gorges? I think Mr. Haddan proposes to employ anchor footings, but I fear they would not be sufficiently rigid for the purpose. I do not think such a structure would work a month; it would get out of the perpendicular. You never could keep it in its proper position; and then it is proposed to go round curves by cutting slightly through the beams, which would take away the strength of the beams; to the extent that you put saw-cuts in the beams, you diminish the strength, and that is not a good plan. The single line, also, does not give you any great advantage in going round curves. With two beams, the rails may be bent to the curves, but for this purpose it is better still to use cross sleepers. Mr. Haddan was saying he proposed to use a double line, 7 feet apart. He also said there was an objection to two rails, even if they were kept in gauge, there was a certain loss of power in the oscillation of the trains, and I think I understood he intended to use these two separate lines as a railway, the two wheels of the same carriage running upon them. It appears that they are about 3 feet above the ground, and there are no cross ties. I should like to know how he will keep these two lines in gauge; it will be impossible; you could not keep them in gauge, and they could not be worked in that way. I entirely agree with Mr. Haddan in this one thing, that earthworks must be dispensed with, but I certainly think a gauge of some kind, let it be 18 inches, 2 feet, or 3 feet, is very much better than a railway without any gauge at all.

M. BERGERON: When I was attending, three years ago, the meeting of the British Association at Bristol, I heard, with interest and curiosity, Mr. Fell explaining his system of a central rail and a very narrow gauge as especially suited for military railways. He described the trial of such railway made with a certain amount of success at Aldershot Camp, and led me to suppose that the English Army, perhaps, would use it on a very large scale. I could not agree with Mr. Fell. His system involved the necessity of transporting an immense number of timber beams and the use of rolling stock of very small size, unsuitable for moving heavy ordnance and large quantities of ammunition, stores, provisions, &c, an exceptional gauge of permanent way for military present serious disadvantages. An army in campaign must receive all its stores and war materials over railways which are in connection with the arsenals, dockyards, camps, and depôts of military engineers. The locomotives, waggons, and carriages used on the railways of an invading country should be able to run over the lines of that country. In the invasion of France by the Germans, in 1870, if the lines of the two countries had not been of the same gauge, the invaders would have found great difficulty in provisioning their armies and keeping up their supplies. I have been told that, during the War of Secession in America, the armies of the Northern States had a great deal of trouble in transporting soldiers and ammunition into the Southern States, on account of a

difference in the gauge of the railways of the North and the South. It is for that reason, and for fear of being too easily exposed to invasion by the French, that the Spanish Government decided to have for its railways a gauge one foot larger than the French ones. For those reasons, it is of the utmost importance that a military railway should be of the ordinary gauge of English and Continental railways. Actually in France, all the railways, in case of war with a neighbouring nation, are to be ruled by military engineers. The Civil Service is entirely suppressed; the rolling stock becomes temporarily the property of the Government, and the Minister of War is the official general manager of all the railways in the country. The goods waggons are already marked with figures indicating the number of soldiers and horses which they will contain, to prevent confusion at the moment of loading. These waggons and carriages can run over all European lines except in Spain and Russia, who have adopted a broader gauge for their railways. I heard the other day, at Paris, that the two Ministers of War and of Marine have requested from the French railway companies the construction of special trucks, able to carry a gun of 100 tons weight. In reality, I can say that all the French railways are military railways. In the Staff of the Army there is a great number of military engineers who are perfectly able to manage and work those lines. I shall now examine the case in which new lines are to be constructed in countries for forwarding an invading army, with all its stores, munitions, provisions, &c.; and, first, I maintain that the materials of which a military railway of the ordinary gauge is composed should be reduced in number and weight as much as possible, and every endeavour practicable should be made to utilize such as can be found on the spot. The earthworks must be reduced to their minimum of width necessary for laying the permanent way in a solid manner on the required thickness of ballast. For this reason, instead of spreading the ballast as it is generally done on the surface of formations, I propose to fill with it trenches of two feet depth, cut across and along the way as represented in the diagram. And we may observe that:—1st. The formation of the railway will have only ten feet in width instead of fifteen, which it must have with the ballast spread on the surface. 2nd. The sleepers are only seven feet long, and they are laid at seven feet distance from each other. 3rd. The ballast is imbedded in the trenches cut along the way under the rails and across the way under the sleepers; the ballast is composed at the bottom of the trenches of broken stones, to facilitate the exit of water of filtration, and, at the top, of common sand or gravel. 4th. The sleepers of usual section, say ten inches wide and five inches thick, are laid on edgeways, and struck with force by a rammer, and brought like piles on their proper depth into the ballast over the bed of broken stones. 5th. Between two sleepers, which are seven feet distant, the rails are supported by four or five blocks of wood of two feet long; they have the same section as the sleepers, and are sunk down by the blows of a rammer to the level of the adjoining sleepers. 6th. After having brought the upper part of the blocks to the same level as the sleepers, the rails are laid on the sleepers and blocks with their normal gauge, and they are bolted with screw bolts penetrating deeply into every wooden support. The advantage of this new mode of laying the permanent way, may be described in the following manner:—1st. Instead of packing the ballast under the sleepers, the sleepers and the blocks are packed, by blows of a very heavy rammer, into the ballast. 2nd. When it is necessary to raise the permanent way, that can be done easily, because the sleepers and the blocks are strongly tied to the rails, and they offer very little resistance to being railed; it is sufficient for filling the hloes produced under the supports to hammer and strike the ballast with heavy blows between the supports and along the sleepers. 3rd. At a depth of ten inches the ballast, well packed, will offer more resistance than when it is packed at only five inches deep under the usual sleeper at its two ends. 4th. With this new system of permanent way, the rails need not be so heavy as those now employed; a rail of twenty feet long, and weighing only 60 lbs. per lineal yard, will have more resistance, being laid upon sixteen supports, than a rail of 80 lbs. per yard, laying upon eight sleepers, for the same length of twenty feet. 5th. When the new permanent way has settled, it is not necessary to keep gangs of platelayers to maintain it; it is as solid and as resisting as if it had been founded upon a range of piles. 6th. The sleepers and blocks laid down on their edge, all less exposed to their injuries of the

weather than the sleepers laying on their large flat surface; and being of smaller size, they will be more easily submitted to the process of preservation by oils, coal tar, or creosote. 7th. The sleepers of seven feet long will be procured more easily, and at a less cost, than the usual sleepers of nine feet long. The blocks which are intended to support the rails between the sleepers will be cut from trees unfit for producing logs of wood of a certain size, and which are used for firewood only. They will be obtained at a very low price, and an invading army in a wooded country will find any amount of such blocks along the roads and hedges. A specimen of this new system of permanent way, which I have submitted to the approbation of several English engineers, is now exhibited in the Champ de Mars, in Paris, and I hope it will be reported as the most simple, the most economical mode which can be produced, as well for ordinary, as well for military railways. But the reason for which I consider it especially favourable for military purposes is, that it can be applied to the side of any common road which may be traversed by armies in campaign. I do not think an invading army will have to build bridges and make deep cuttings for lines entirely new. It is more easy and more economical to use the common roads, without taking into great account the heavy inclines and sharp curves which may be met. We know that the Mont Cenis, between France and Italy, has been crossed by a railway made on the side of the main road, very tortuous, and in which there were inclines of more than $\frac{1}{10}$ gradient. I have seen in the office of Mr. Longridge a model of a locomotive, of his own invention, which would be perfectly capable of drawing upon such an incline a heavy train at the speed of twenty miles per hour. In time of war, the economy will not be the chief consideration in the working of a military railway. In case of emergency, when one locomotive is insufficient to draw the train, the staff engineer will order two; if two are not enough, he will put three, and so on. I recollect having seen, in 1842, an excursion train for passengers from Leicester to Matlock. There were seven locomotives at the head of the train, which was nearly one mile long, and going very slowly. Nothing would prevent a General-in-Chief from organizing trains with a sufficient number of locomotives working together, for ascending the inclines which may be met on the common roads transformed into railways. Let us suppose a road of thirty feet wide, the permanent way described above may be prepared to occupy only one-third of the road space, or ten feet. It was arranged so with the Mont Cenis road, which had still twenty feet left for the ordinary carriage and cart traffic. If the ordinary transverse sleepers above the formation should be employed, half of the road, or fifteen feet, would be occupied for a military railway of the usual gauge. To the plan of Mr. Fell, who admits that an army should carry all the materials necessary for building a railway through the country, I would object that such a plan would be very expensive, and produce very little advantage. I am certain that the more simple process for having a railway in an invaded country is to utilize the main carriage roads, where all the earthworks, bridges, culverts, &c., are already built. The soldiers could be occupied in as great numbers as might be necessary in digging the trenches into the road, filling them with ballast, cutting the trees, and making sleepers and blocks. The sleepers being shorter than those actually in use, will be lighter and more easy to be carried on the shoulders of the men, and every soldier will be able to transport in his arms a couple of wooden blocks a long distance to any place on the road where they may be wanted. An invading army has nothing else to carry but the rails, fish-plates, bolts, nuts, spikes in a sufficient quantity. In such conditions, with any number of soldiers acting as navvies, workmen, carpenters, platelayers, it would be possible by a convenient distribution of the gangs to lay down a permanent way of ten miles a day. For these several reasons, I conclude that my system of permanent way could be very advantageously used for military railways.

Mr. FELL: It has been said the system of railway I proposed to the War Department is very expensive. The War Department has received a tender from very responsible contractors to construct the railway at 2,500*l.* a mile, which is a very moderate price. I may just add that in some countries where there is no ballast at all M. Bergeron's system would be rather difficult to carry out. Longitudinal timbers might be used instead in places where ballast could not be readily procured.

Admiral SELWYN: Having been instrumental in getting this paper read here, I

feel called upon to offer a few observations upon it. And I shall take occasion first to regret that gentlemen should come here with an object not of discussing the paper which is read, but of opposing some other paper to it. We shall always be happy to listen to their own papers when they come to read them, but it is scarcely fair treatment that a gentleman who comes here with a certain idea should not have it fully and fairly discussed as it is. We always regret it, because the Institution learns less than it would otherwise do upon the particular subject it is discussing. I can only say, with regard to the single line of railway, that having been a very long time in America among the mines in the Rocky Mountains, I have seen very great reason there to value the single line of railway. First of all, it has the great convenience of doing away with the weight of the engine as the cause of traction; it thus removes the principal objection to the sharp descents and inclines which we have to deal with in mines. Secondly, we often find trees very well placed indeed to serve such a railway where we could not find them placed so as to serve a double track. I can quite understand that the instant you tie yourself to the traction by weight, that instant you must leave the single line, if you have devised a single line, and gradually recur to the gauge of double line generally adopted. But in doing that you will abandon all the special advantages which the single line offers. You certainly abandon the cheapness; you abandon a great portion of the simplicity, and you increase enormously the number of pieces to be carried to the place where the railway is to be established, you may say you double them. What we are dealing with here is not the question of a set of military railways which are to be used thereafter for traffic for a long time, but that peculiar state of things in which you have to traverse a difficult country in a very short time, where you cannot afford the time for embankments or even the ordinary surveys, and where you yet must have some means of conveying those enormous weights which modern science has imposed upon military marches. If we will have guns of heavy calibre, if we will have breech-loading arms, we must have greater weights than we have ever been accustomed to carry before, and it is perfectly vain to expect that either by mule or cart transport we can overcome difficult countries with the rapidity which it is desirable to obtain on these occasions. Therefore, anything which promises to give us such a railway as can be easily and with facility constructed, although it does not present all the advantages of a future employment, is worth serious consideration, and it seems to me if one or two points of difficulty are overcome there is a great deal in the system which balances weights on a single rail instead of resorting to the broad base to support them from below. If the centre of gravity is low down there is much less tendency to oversetting on curves. We know also perfectly well that wind is an important factor in some countries, as I can vouch for, having been on the third occasion of my going to the Rocky Mountains stopped one whole night on the line of the Union Pacific by wind. Therefore, you may imagine we do sometimes in elevated regions find something which is rather difficult to deal with in any ordinary way. The question of the mode in which Mr. Haddan proposes to support his road seems to me to have been very ingeniously met. His strutting leaves very little to be desired as regards the rigidity of the structure; and as for the question of the bearing of the piles, I presume that is not more difficult to meet than we find generally the case in any standard which are used for other purposes. We generally find an engineer meets the particular conditions of a particular soil with the greatest facility by adding struts, whatever it may be. But the question I I should like particularly to ask is this, whether he has found in such experiments as he has yet made any difficulty arising from the compressibility of the wood. In Canada they have successfully run ordinary engines on lines of wood with nothing but a thin strip of sheet iron along the edge of the wood; but where heavy engines were used, and heavy loads were carried, there was a compression of the fibres of the wood during the passage of the train, a compression which is to be noted in iron rails, but which would be probably much more sensibly felt in a wooden rail, particularly when it was wet. Then there comes also a difficulty which occurs to me with regard to the swelling from wetting to be expected even in seasoned timber, and I do not think in such a case we can always rely on the whole of the rail being made of seasoned timber. All these are questions which only experience can answer. Meanwhile I think we may fairly say that he has brought down the cost,

he has brought down the time of construction, and has increased the possibilities of ascending and descending inclines. If this line were made, even if the rail did not carry all we hoped to see it carry, if by dint of a double line you are not able to devise a special carriage for heavy guns which would traverse, and by its very traversing keep the rails in gauge, which is very easily conceived by an engineer, I should imagine, for I speak with the greatest diffidence in the presence of Mr. Fell, still I think there is something to be gained in a new view of the subject which this seems to be—that Mr. Fell has done all that could be done with the ordinary locomotive I have no doubt—with the ordinary disposition of weights and the ordinary means of acquiring a grip. But this is quite a new way of doing the same thing, and it is worth while to consider how far it may be utilised, taking into consideration also that we are now getting to understand the means of carrying power in a much lighter form. In the course of this year we shall see boilers which do not weigh one-fourth of the ordinary boilers for the same power. We are resorting to higher pressures; we are ceasing to be afraid of what is called high pressure; but I have never been able to learn yet what was high and what was low, since the very man who would remonstrate if you put him on a steam ship with 100 lbs. pressure does not hesitate to go behind a locomotive with 120; in fact, I do not think he would care if there were 300 lbs. per square inch on the safety valve. I recollect the time when at sea we ran with the greatest contentment at 15 lbs. above the atmosphere, and we thought we were doing wonders. Latterly we have learnt to know that it is a very different thing, that there are enormous economies to be gained in that way of which this railway may be one of the first examples. As long as we stick to the old type of locomotive we cannot do better than have a broad basis of support. As long as we stick to the old-fashioned form of laying rails on sleepers—we have changed from iron and stone sleepers, and have gone to wood as the best after all,—so long as we do so we cannot do much better than experience has taught us to do. But the instant you adopt a new plan altogether all these objections disappear, and when we consider that it is likely to give an enormous power into the hands of any military commander which he certainly never could have had before. I think it is worthy the serious and close attention of this Institution.

Mr. Russell Shaw: If no one else wishes to say anything on this subject I shall be glad to say a few words, having been some time in charge of the railway in the Crimea, and having had a good deal of experience in other countries, and also with the movements of large bodies of people. When I look at these drawings, and listen to the remarks that have been made—rather personal ones on their own particular hobbies—by some of the speakers, I cannot refrain from thinking of a thing that occurred to me in South America, where I once bought a small machine for peeling potatoes, like a small lathe, with a spring to it; you put the potato in, turn it round, and the peel comes off beautifully. I gave it to the cook, and said, "What do you think of that?" She said, "Next to an old knife I think it is "the best thing I have ever seen." Mr. Haddan has brought before us a railway for military purposes, which appears to me to play the part of the mechanical potato peeler. Now, during the Crimean War we had a railway, but it was not very successful; a railway was provided in the Ashanti War, but it was useless. What you want is a railway as to which you can dispense almost entirely with any skilled labour and engineering, where you can dispense with plans and surveys beyond those which an ordinary corporal of sappers can give, and where you can take the whole of your permanent way from the deck of the vessel to the end of the point you are attacking. Mr. Haddan pointed to one thing in which I must say I agree with him entirely—that is, that no military railway should be complete unless it is with a double line of rail. If you are to have a single line of rail, with sidings, you had better leave the thing at home, save yourselves the money, and trust to donkeys and carts, for such a railway is of no earthly use. But I must say I do not agree with him in the least as regards the whole of his scheme. It is no good attempting to praise it when you do not think you can praise it deservedly. That ingenious contrivance is very well suited for countries such as Chili. I cannot conceive a better; but that line would be equally ridiculous in Pera, because there are no trees, and it would cost a very large sum of money.

Mr. HADDAN: Make it in iron.

Mr. RUSSELL SHAW: In taking an army into the field you have to take a number of men. A certain number of men require a certain number of tons of supplies. This number of tons has to be moved a certain number of miles, and on that you base your rolling-stock; on that depends that whole question. Heavy rolling-stock must have heavy permanent way and heavy engines; therefore, the principal point is to diminish the weight of the permanent way within proper limits, so that you can make available first your cavalry horses, secondly your infantry men, and when these fail you, your camp followers, because at a price the British public can always pay somebody to push. The question of gradients of course is a very important one. Up the Balaclava incline, 1 in 14, the engine used to take up its own weight and one empty truck. With horses, and without locomotives, you can get up any gradient, I do not care what it is, 1 in 2, even up the side of a railway cutting. I understood this was to be a discussion on military railways, not a discussion on Mr. Haddan's paper alone, but suggestions to be thrown out by other people. Mr. Fell has given us the benefit of his experience; M. Bergeron has told us what would do very well in France, where you have any quantity of roads, but I presume the attention of the public, and of this meeting, is devoted more especially to the events in the East, where there are no railways in existence, and where probably, or perhaps, some events may take place which will necessitate the construction of some kind of railway, whether it be on Mr. Haddan's or anybody else's system. That is a matter which of course is not left to this meeting to decide or to give an opinion upon. That decision rests with those who think they know a great deal better than any one here present; whether they do, or do not, will probably be found after the event, as was the case in the Crimean War. One of the most difficult things for a person who is not accustomed to speak is to wind up his subject, and that is precisely the difficulty I find myself in. I have criticised Mr. Haddan's very valuable efforts. I have made some perhaps not very polite remarks about other gentlemen who have gone away, and I have nothing to offer you in exchange, because without plans, without designs, without samples, and without figures, it is impossible to bring anything before you. If this meeting is adjourned, and the chairman and others take any interest in the matter, I shall be able to bring forward plans and designs of railway, which have been proposed, and then probably a further discussion may take place. In the meantime let us hope that war will be over, and that nothing will be required, and then we can discuss the subject on a more peaceful footing.

Mr. PERRETT: Mr. Haddan told us at the beginning of his paper that he had abandoned the principle of adhesion by gravity, and had adopted adhesion by grip. Subsequently he said he had abandoned adhesion by grip, and had reverted to adhesion by gravity, the only difference being that in the latter case he proposes to utilize the entire weight of the train. But he did not give us any particulars by which the entire weight of the train is to be utilized. As the value of the arrangement depends entirely upon the particular mechanical means employed, if he would give us some indication of the manner in which he intends to effect the desired object, it would add greatly to the value of his paper.

Mr. HADDAN, in reply, said: First in the order of my reply is Mr. Fell. Mr. Fell in his former paper declared most positively that his line did not interfere in the least with vehicles crossing, and now he says that it does interfere with them. I have explained in my paper how I make my structure so that it shall not do so; consequently his observation does not apply to the Pioneer. His remark that the Pioneer requires special rolling-stock is perfectly just. It seems to me an army cannot properly use makeshifts, but requires special guns, special bayonets, and special everything, and endless training in their use. And this applies to a special railway like mine, which, though only to be used in war, should be kept in stock just the same as we have thousands of tons of shell, that might never be fired; for it is in the highest degree uncommercial for a military organization to rely upon the civil transport supply of the country it is operating in—especially if a friendly one—since it must seriously, sometimes fatally, interfere with trade. The 60,000 camels lost in the Afghan campaign are estimated at one-third of the transport power of the Punjab; equivalent in England to 200,000,000*l.*, or one-third of our railway capital. The same rule applies to cutting local timber for fuel, instead of transporting it. Egypt is a striking example in point. Mr. Fell

advocates points and crossings; now my experience is, and I have no doubt most of you are of the same opinion, that the generality of the accidents that occur on railways are due to points and crossings, and the facilities they afford for one train crossing another's path *in an opposite direction* on the same level, a danger experienced at all junctions. An instance in point is the double junction curve on the South Eastern Railway at the Surrey side of the Cannon Street bridge; where no *down* train can enter or leave the station without crossing all the *up* lines, and *vice versâ*. Shunting across the main line is also a no less fatal facility afforded by points and crossings in ordinary railways; but the Pioneer devotes a separate line to each class of traffic, and consequently eliminates all the well-known dangers and delays caused by working varying speeds, &c., on one system of rails—even with a highly trained staff. I glory in the fact that I do not want them, though I can use them if required, as should never be the case; military transport being regular, and not a combination of fast and slow, express and goods trains, &c. Mr. Fell has a very ingenious way of getting over the strength of the argument shown in the section in the diagram (Plate 5, figs. 3 and 4) by saying the scale is "exaggerated." All engineers in drawing their sections exaggerate, the scale being ten times vertical scale to one horizontal, and both are treated alike. By half measures he proposes to get over that pertinent remark of mine of the 20-foot viaduct by saying, "We won't make a 10-foot cutting, we will make it 5." But he cannot reduce his cuttings without increasing the grades, which at Aldershot were already positively prohibitive. An elevated railway should do away with earthworks altogether, or it is of no use whatever. By stating that the height of the viaduct at Aldershot could have been reduced, by *choosing an easier path;* he proves beyond question that his system is not suited for military purposes, since a military railway should know how to obey orders and go anywhere, and not as it were make excuses.[1] Mr. Fell's structure weighs 250 tons per mile in lieu of 50 tons, which is the average weight of the Pioneer, and as my structure is much simpler, the chances are that if he managed to erect two miles a day, I ought to do six. The word "failure" I applied to his system, not as a mechanical failure, but if you refer to my lecture, you will see I explained that mechanical triumphs often prove the most pernicious of successes. The work done was certainly a failure, for it was no great success to take 14 tons of stores up an incline of 1 in 50. I would ask Mr. Fell what weight it is possible to take up with a grip engine, and why he drives his vertical wheels at all when grip is a power so much superior? and also, with the view of proving its commercial non-success, would I inquire how much money the late Mr. Brassey lost on the Mont Cenis Railway? I believe over 100,000*l*. I would also remark in reply to his question about driving in stones to support the uprights; that when in an argument people discuss a drawing done by a scenic artist, and say, "That is not strong enough," or "That man does not look to "me in military costume," or "Because stones are painted in the picture, you must "use stones," I think, when you come to arguments of that kind, they certainly show that more valuable criticism is not forthcoming, especially when the various weak, or I may say fatal points in Mr. Fell's system, are not even defended or explained by him. Mr. Fell has also said that "beams lose their power when they have cross-cuts "made in them." I may reply that if his 20-foot posts are cut down to 5 feet for use

[1] The eminent railway engineer, Mr. J. W. Grover, says :—"My first reason in "advocating Mr. Haddan's system is founded on the great difficulties which cuttings "and embankments offer to even the simplest form of narrow gauge railway construc-"tion, difficulties only known to those who have to deal with them in practice. So "great are they in foreign lands where labour is difficult to get, and contractors with "sufficient plant are wanting; that the fashion now obtains amongst engineers of "making the line meander round the hills in very serpentine courses—thereby "enormously increasing the length of the line, and involving sharpness of curve, which "would have shocked the original inventor of railways. The constant tendency to "sharpen the curve and increase the gradient—shows the false direction to which "the wants of civilization are urging engineers from year to year."

with the Pioneer they become four times as strong, so that such a general observation is incorrect, as you can judge for yourselves. When cross-cuts are put as I have put them, and the beam is merely compressed, and carries no weight, it would certainly not weaken the beam. Mr. Fell has put arguments into my mouth which I did not use, for fault of others I presume, and then naturally enough he can destroy them. With reference to his statement that he had tried all that I had, and found that it did not work; such statements require serious support, nothing of the sort being found in Mr. Fell's numerous publications which I have carefully studied so as to avoid the rocks he has split upon. I can only tell him that if he had done so, he would never have tried on the Mont Cenis Railway to combine gravity with grip—oil and vinegar—a solecism I should be very sorry to acknowledge, and which marks most undeniably the difference between his system and mine; nor would he continue to harp on the *weight* of my locomotives if he understood my principles in which weight does not form an element for calculation. It was consequent on this erroneous combination, and on the grip being applied by hand grossly in excess, that his engine would only draw 30 tons on 1 in 12, although the steam-power used was theoretically capable of performing four times as much; showing beyond a doubt that Mr. Fell did not understand that since grip adhesion merges into a brake, too much adhesion was as bad as too little. With reference to the supposition expressed by Mr. Fell and also by many non-technical observers, that the Pioneer road might turn over, practice has not manifested the least tendency in this direction; although in the American oil fields, double banked cars 28 feet long, and weighing over 10 tons, have been used. Nor was any such effect to be anticipated, since theory shows that the weight is under every condition exerted strictly vertically, and that any unequilibrated lateral thrust such as could be offered only by the cars, when rounding a sharp curve, is entirely borne by the *lower* part of the structure near the ground. Hence no leverage or motion of any sort can exist at the apex, performing as that part of the structure does, the function of the pivot or fulcrum of the lever; which every one knows is a neutral point. The opposing grip wheels of the engine, the only points where anything like serious lateral power is exerted, neutralise each other to perfection; so whence then can come the force, which is estimated at 50 tons, required to turn over the sturdy structure, whose proportions I have so carefully elaborated. Fences and gate posts, with which many are apt to compare the Pioneer, very rarely preserve the vertical; because they lack the constant weight on top which ensures its stability.

With reference to M. Bergeron and his remarks, he comes from Switzerland, the country *par excellence* of good roads. I do not say it is an unfair prejudice, but it shows there is nothing like leather; he has been so accustomed to good roads that he thinks nothing can be done without them; though how he would carry a fair load, with a locomotive, over even the first class road grade of 1 in 20, I am at a loss to discern. If he had been in the countries I have, where there are no roads at all, he would see that his plan of permanent way would in such countries be utterly useless. I have to thank Admiral Selwyn for his sailor-like straightforward remarks. He has hit the nail on the head when he says, "I can quite understand that the instant you "tie yourself to the traction by concentrated weight, that instant you must leave the "single line, and gradually recur to the gauge of double line generally adopted;" in fact, Mr. Fell found this truth out by experiment, but did not profit by it, as I have done in fitting a non-gravity engine to a single rail. Wood is certainly not likely to give such a splendid level road as steel, yet when you have only one rail, inequalities are not felt as they are with two. I said that where wood did not exist I would use iron, and where they could not afford one or the other I should use concrete, and concreting can be done in Syria at 400*l.* a mile. The only objection I have to Mr. Shaw's remarks is that he calls my system "little." I would like to know what system can do as much. Can the broad gauge on 1 in 10, and can it be beaten like the broad gauge by horses? Mr. Perrett wishes to know the details of the continuous driving which I referred to, but I must decline to explain them further for the present.

The CHAIRMAN: Gentlemen, I am sure you will all agree with me that the lecture and discussion have been extremely interesting, and I dare say you all regret, as I do,

that in the course of the discussion there has been a little acrimony introduced, which I think is to be regretted, because we are all entitled to our opinions, and in discussing these various systems of railways we have only one object in view, that is, the good of the service. I have not many remarks to make. I am not an engineer, but I wish to remind my hearers that the English was the first nation that ever used a railway in war, and I am very glad to see here a gentleman who took such a prominent part in it, a gentleman I had the pleasure of knowing in the Crimea in connection with the railway there, and although financially it was not a very great success, it was of great use in many ways. With regard to the construction of military railways, it is not the question of money, of expense, that is of the first importance, because when a nation like England goes to war, it really is prepared to expend any amount of money as long as it is believed that such expenditure tends towards success. But the great question in all military structures like railways is time—time and material. Whenever we go to war, our base of operations must naturally be on the sea, and operating inland, it will always be of the first consequence to us to have a good line of communication from our base to the furthest point we reach. In order to secure that, if no railways already exist in the country that becomes the theatre of war any system that will solve that great difficulty of rapidly providing us with a good line of communication is one well deserving of consideration. I think, therefore, the lecturer, who has brought forward a very clever invention, whether entirely his own or adapted from the inventions of others, deserves very great credit for having done so, and for having explained it so clearly this evening. There may be some very small difficulties in the way of constructing this railway, but I have no doubt under his superintendence those difficulties would be overcome. As far as I can judge of other systems that have been proposed, I do not think it would be possible in a military sense, that is, during a campaign, to make the great cuttings which are required in all other systems of railway. I do not believe the construction of great cuttings and earthworks would be possible during any ordinary war. If you are to settle down before a town and besiege it for years, like the siege of Sebastopol or of Troy, of course that would be a different thing; but if you are to make a campaign, and we all know campaigns of the present day are rapid and must be carried out very quickly, a railway of a temporary nature, that can be sent almost complete from England, and that can be laid down in a country where there are none or few roads, is what we want for military purposes. If you have good roads in a country, you can lay down an ordinary system of railway or of tramway, and my friend Mr. Russell Shaw has, I know, a plan for rapidly laying down a temporary railway under those conditions, and an admirable system it is; but, with all due respect to his invention, I think that, in order to lay down a railway after his pattern, it would be absolutely necessary you should have good roads to operate on. For in a country where there are no roads, a system such as the lecturer has proposed this evening seems to be very fairly adapted. I have nothing more to do except to thank the lecturer and those gentlemen who have taken part in the discussion for the valuable information they have afforded us.

HARRISON AND SONS, PRINTERS IN ORDINARY TO HER MAJESTY, ST. MARTIN'S LANE.



View in The Transvaal. (*From 'The Graphic.'*)

THE PIONEER

OR

STEAM CARAVAN;

WHEREIN CONCENTRATED WEIGHT IS SHOWN NOT TO BE EITHER NECESSARY OR SUITABLE FOR OBTAINING TRACTIVE POWER.

BY J. L. HADDAN, M.I.C.E., F.R.G.S., F.S.A.,

OFFICER OF THE MEDJIDIE, FRANCIS JOSEPH, ETC.

EMBRACING ALSO A SCIENTIFIC REPORT ON THE SYSTEM

BY J. W. GROVER, M. INST. C.E.

WITH

THE OPINION OF SIR GARNET WOLSELEY, ETC.

See page 55.

In countries where statistics are not procurable: Pioneer or semi-portable Railways, alone admit of the ready correction of errors in judgment which are inseparable from that vigorous prosecution of public works,—which the age demands. It courts success by observing a perfect subservience of technical means to commercial wants, in lieu of the usual apposite; combined with non-interference with nature, property, or the labour market, the three costliest items of ordinary Railway construction: while its moderate price, enables personal management to take the place of joint stock administration. It is designed also to form in its entirety a staple article of home export: and to eradicate the famines chronic in large continents, due to deficient intercommunication.

Re "AFRICA OUR SECOND INDIA," *Mr. Bradshaw's Project; see page* 56.

Entered at Stationers' Hall.

LONDON:

PRINTED BY WILLIAM CLOWES AND SONS,

STAMFORD STREET AND CHARING CROSS.

1879.

Price 2*s.* 6*d.*

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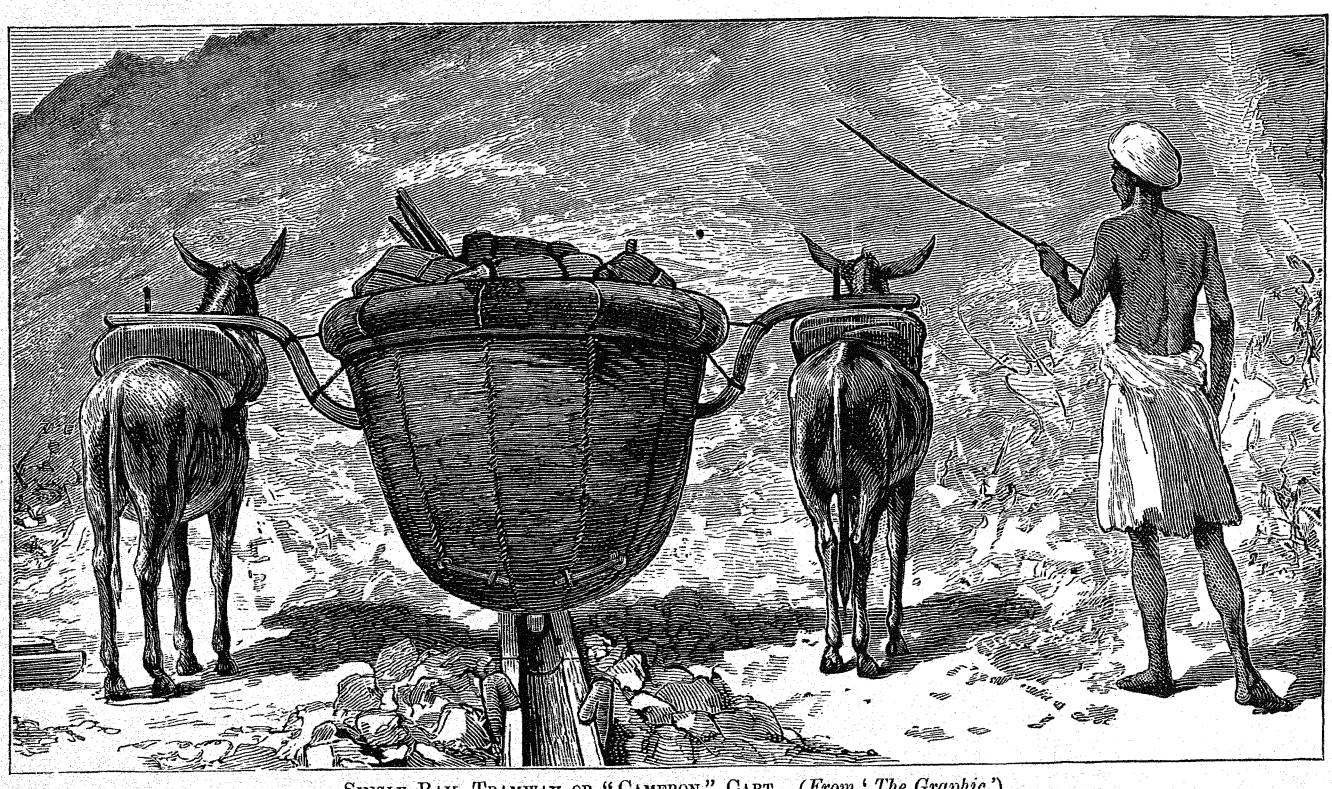
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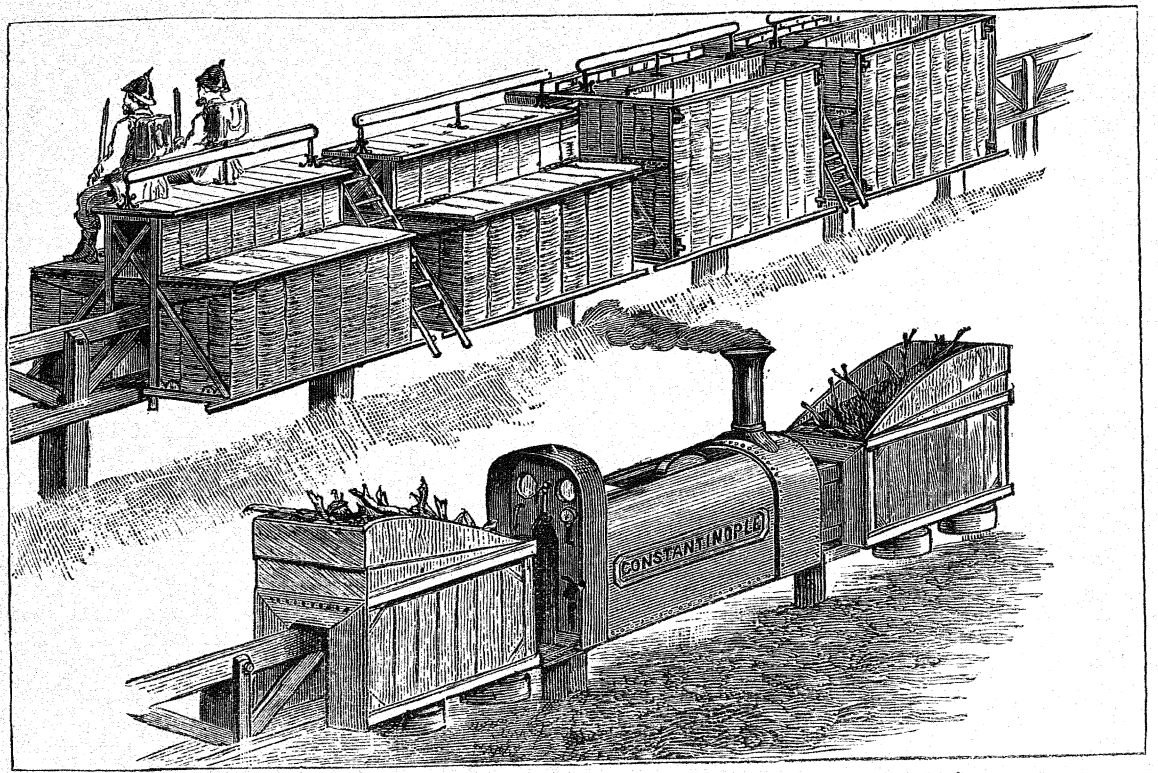
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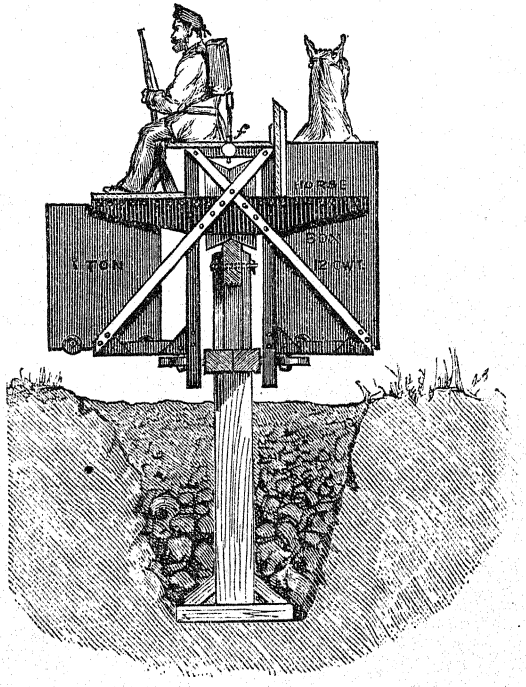
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SINGLE RAIL TRAMWAY OR "CAMERON" CART. (*From 'The Graphic.'*)



SKETCH SHOWING ENGINE AND COMPOSITE CARRIAGES. (*From 'The Graphic.'*)



CROSS SECTION—MILITARY RAILWAY.

This half shows the skeleton carriage as arranged for both passengers and boxes of goods. The box is mounted on wheels; it is shown partially withdrawn.

This half shows the same carriage arranged to carry cattle-boxes: the passenger flooring being simply turned up.

(*From 'The Graphic.'*)



"THE TÂKTIRAVAN." *The Origin of the* PIONEER.

ON OVERCOMING GEOGRAPHICAL OBSTACLES TO AFRICAN TRADE; BY ECONOMICAL ANIMAL AND MECHANICAL EXPEDIENTS.

By J. L. HADDAN, M.I.C.E., F.R.G.S., F.S.A.,
Officer of the Medjidié, &c.

EMBRACING ALSO A SCIENTIFIC REPORT ON THE SYSTEM,
By J. W. GROVER, M. Inst. C.E.,

WITH

The Opinion of SIR GARNET WOLSELEY, Etc.
(*See Page* 55.)

[*A Paper read before the Royal Geographical Society, Session* 1878.
Sir Rutherford Alcock, K.C.B., *in the Chair.*]
(30th Edition, revised November 1st, 1879.)

When we consider that the area of Africa is about one hundredfold that of Great Britain, even without entering into the question of the comparative wealth and density of population of the two countries, the disparity is so great; that it is self-evident the usual stereotyping of European railways is quite out of the question, when considering the suitable means for opening up Africa.* Her Majesty's Ministers offered our profession some very valuable suggestions on this head, at the Anniversary Dinner of the Institution (see Extract, p. 59; and Grover's Report, ¶ *f.* page 64).

In addition, the modest 5 per cent. interest tardily achieved by some English lines, may satisfy the stay-at-homes; but the risk in Africa both to life and purse, warrants a return of at least 50 per cent. on any capital ventured under existing circumstances.

It is the purpose of this Paper to point out that this may be done expeditiously and surely, *simply by making the mechanical means employed, thoroughly subservient to the special commercial wants of the case in question;* instead of adopting the usual plan which is

* Short-sighted persons have hastily condemned steam *in toto* for this reason, although the one is 300 fold more economical (in England) than the other.

diametrically opposite, viz. of imposing English railways *en bloc*, without any regard to the requirements of the country treated.*

1. A railway or other means of transport, to pay its shareholders an ultra dividend; should, upon the accepted principle of supply and demand, never be constructed on a scale one tittle in excess of the traffic existing.

Remunerative railways proper cannot, however, unfortunately be constructed in miniature except on the flat; since, whatever the scale may be, a heavy locomotive is obligatory: moreover, when the grades are steep, the dead weight is so great and the paying load so reduced, that the rates become prohibitive, since the train becomes practically all engine.† The first giant stride in economy the Pioneer performs, is abolishing all necessity for extraneous weight in the locomotive or brakes. Hence the train is light and of equal weight throughout, and the permanent way can be constructed of a strength sufficient only to carry the traffic unit, whatever it be; in lieu of being called upon to support the arbitrary weight of a locomotive: which over difficult country may increase the calibre, and therefore the cost of the whole line, at least tenfold the freight requirements. A Pioneer train will not weigh per yard one tithe as much as a Fairlie mountain-engine and its brake vans, although the freight carried by the Pioneer train would be superior.

Ex: In the mountains of the Mauritius a single line of railway cost 22,000*l.* per mile, yet in bad weather the speed did not exceed four miles an hour on a grade of 1 in 45. The gross load of the train was 131 tons, of which only 23 tons, or $\frac{1}{6}$th, was freight: while a Pioneer train of like weight would carry three times the nett quantity, or 70 tons (see Grover's Report, ¶ *b.* p. 64): With a maximum goods tariff of $5\frac{1}{2}d.$ ‡ per ton per mile, the dividend was only 1 per cent.

* Instance: In Natal the summer or working season is very rainy, necessitating an extensive system of ultra good roads; while in Canada roads are but a secondary consideration, since the winter snows provide gratis the best possible road surface, viz. frozen snow: a mild winter being a positive calamity. The Zulu campaign has also shown us how little the vast superiority of our ultra-perfectioned war *matériel* avails us, when used in combination with primitive transport, which leaves a general at the mercy of the weather. It has also shown us the folly of increasing the area of our nominal rule at a greater speed than we can open it up, and points to the use of railways in warfare, as a means not only of immediately securing what we take; but of literally converting our swords into ploughshares by allying commerce and war, instead of ruining the trade both of ourselves and the enemy by exterminating the only commercial means of transport available, viz. animal: one which money cannot replace.

"But to all present seeming, the transport problem closely approaches the insoluble; and it would occasion me no surprise should the transport difficulty involve us in the necessity of a second campaign."—'*Daily News' African Correspondent.*

† *Twice* the grade means a reduction of *four* times the load. (See Grover's Report, ¶¶ *b.* and *c.* page 64.)

‡ The average Indian tariff is less than 1*d.*

The Pioneer is a one-rail railway, the permanent way consisting of *one* elevated rail supported upon dwarf posts. The rolling stock is arranged donkey and pannier fashion, the load hanging down on either side of the rail to the extent of about 2 feet 6 inches. The nominal height of the rail above the soil rarely exceeds 3 feet.

The Pioneer alone can use such a light elevated structure by which all physical difficulties are ignored, simply because it attenuates the load and effort, instead of concentrating them. Mr. Palmer, Mr. Fell, and other eminent engineers who have attempted to render practical the tempting advantages to be derived from such semi-aërial railways; have simply failed because *their* engines, like locomotives in general, required concentrated weight.*

2. To construct railways in uncivilised countries, cheaply, expeditiously, and to an unlimited extent if desired; *the maximum of the labour should be performed in the European workshop, and as little as possible undertaken on the ground.*† In Africa is this the more imperative owing to the sloth of the natives.

Earthworks and masonry must therefore be eschewed, and their cost which is excessive, while they are of no intrinsic value, is far better spent at home, than in upsetting the labour market and the revenue abroad; as all large enterprises have been found to do, especially in agricultural empires. With earthwork railways, unless "there were seven Stanleys in the field," sufficient men could not be kept together *at any price*, to make 300 miles of railway in three years, much less keep it in order;‡ while the European

* On the Discussion of the Pioneer system at the United Service Institution, Admiral Selwyn said, "I can quite understand that the instant you tie yourself down to traction by concentrated weight, that instant you must leave the single rail, and gradually recur to the gauge of double rails generally adopted."

† Average railway works require 30,000 days' labour per mile. Permanent way and stations *not* included. (See Grover's Report, ¶ *g*. page 64.)

‡ The preservation of earthworks, or even the ballast, against tropical rains, is costly in the extreme; often all but impossible in fact, and quite so commercially: the annual outlay for their maintenance against the weather alone may be capitalized at £1000 per mile in normal cases, and as much as £4000 and £5000 in those tortuous ravines which so often afford the only feasible ingress to continents. The Pioneer therefore starts with a negative guarantee of this amount, since it dispenses with earthworks. In the Parliamentary discussions on the Indian Budget, Mr. Onslow drew attention to the Pioneer's principles in the following words: "He hoped, therefore, that in future no works would be entered upon unless there was an assurance that they would be reproductive. It should not be forgotten, he might add, that large sums had to be spent on repairs; for hon. members generally could scarcely be aware how soon such works became deteriorated in the climate of India." In making comparisons between various systems, the actuary's calculations should therefore supplement the Engineer's prime cost estimate. Ex.: Although macadam costs less than one-half the price of stone pavement, its maintenance is nearly five times greater, and to compare only their first cost as a criterion of respective value would be manifestly absurd.

and American markets could cover the whole of the "dark continent" with an *iron* Pioneer road in that space of time. It is moreover a positive sin to degrade men to the treadmill of earthworks, when agriculture and trade demand all the hands that can be got.

When machinery (tip-waggons, rock drills, &c.) is employed for the construction of earthworks, the cuttings are purposely made of the same cube as the banks: but when earthworks are made (literally) by hand as in India, cuttings (being harder to work) are all but tabooed: the rule being 3 bank to 1 cutting.

To grade similar country it therefore requires nearly threefold the amount of earthwork in the one case that it does in the other. The number of labourers is still further enhanced by their individual feebleness, which experience shows does not warrant even the expense of supplying them with any but the most primitive tools—such as baskets and hoes.

Sir Theophilus Shepstone, when annexing the Transvaal, acknowledged this. He exempted the Boers from military service, because their labour as agriculturists could not be spared. General Cunynghame has also shown what complications may arise, in employing large masses of native labour. He says the Kafirs had to be bribed by the contractors with rifles, as an inducement to work. He states that 400,000 stand of arms are now in their hands, and liable at any moment to be turned against ourselves.

Mr. Consul Skene, referring to the Euphrates Valley Railway, emphatically declares that the country will be ruined agriculturally; if the railway is undertaken with local labour.

3. In uncivilised countries, where ordnance maps and statistics do not abound, *every public work should be provisional*, especially if we would act with vigour; since we leap in the dark, and cannot foretell what direction trade may take in the future. This rule is especially applicable to harbours* and railways. Every line drawn upon the map of Africa at the present date should be as it were "a faint dotted one."

Ordinary railways, however, do not fulfil this great economical requirement, for even the narrowest gauge earthwork railway is a permanency, a line indelibly scored on the map; nor can it be either enlarged to a broad gauge, or removed elsewhere, if its original direction be found unsuitable in a sanitary or commercial sense. Hence it is absurd to suggest making roads with a view to their after-conversion into railways,† or of narrow-gauge lines

* Exposed ports should be sheltered by means of floating-surface breakwaters, made of any local materials suitable to produce a similitude in structure and effect to the sea-weed reefs of the Pacific. Manilla fibre would do.

† Mr. Large, C.E., tells me that a line recently surveyed by him in Columbia,

to be converted into broad-gauge when required; for in both cases the curves and grades and even the route suitable for the former, would not be available for the latter. They are both deeds done for ever; for better for worse, as luck will have it.*

The Pioneer is readily transportable; it follows the natural undulations of the ground without disturbing the soil; it requires neither banks nor cuttings (see Grover's Report, ¶ *g.* p. 64), and does not interfere with the watersheds, a most important element in the tropics.† The rolling-stock is handy and can be shipped in running order, the generator weighing only 4 tons. The telegraph wires are snugly stowed under the lower rail out of harm's way. If it is urged the Pioneer is destroyed, it is as readily repaired. On crossing a tidal river, the line may be temporarily laid in the river-bed itself, the construction materials being able to keep the track even when entirely submerged.

The Pioneer train is a continuous metal skeleton formed of waggons of one type, which can be used either for passengers and merchandise, or for goods only and for animals by merely turning up the seats. Each double carriage can carry either sixteen men and four boxes of 40 cubic feet each, or four boxes of 240 feet aggregate; and in addition, bulk to the extent of two bundles 7 feet by 6 feet by 4 feet (say hay). They weigh 30 cwt. each double waggon. (See page 7.)

They are formed into trains of about 30 waggons each, and are never detached except for repairs.

They are coupled at the *roof* level by means of flexible or rather hinge-like joints, which admit of no lateral play. Consequently, although the train is articulated, the natural tendency to overbalance of each individual waggon, is restrained by its neighbours fore and aft; and consequently the average load of one side of the train is available as compensation for the average load of the other: and thus unequal loading of units has no palpable effect, and we shall not be required, as in pack-loading, to add on huge stones to maintain equilibrium. The length of each articulation of the

though only 70 miles by the mule track, required a railway over 300 kilometres in length. (See Grover's Report, ¶ *g.* p. 64.)

* The confusion of the gauges in Australia would not have occurred had the railways been provisional in the first instance; nor would protective duties be necessary, if remunerative railways had existed, to offer a sufficiently attractive inducement to local investors. The colonial capitalists have been forced by English railway loan facilities to compete with our manufacturers instead of confining themselves to producing raw materials. (See Railways and Free Trade, page 60.)

† Even in Portugal the winter rains of 1878 have caused so much damage as to necessitate the reconstruction of many of the Railways.—'*Times*' *Oporto Correspondent.*

train is about double that of the intervals between the posts; and the wheels are so arranged that the train in running over the permanent way, only bears upon the posts and not upon the span.

The train really forms a *short* perambulating beam, and therefore absolves the permanent way from the necessity of providing interminable quantities of this expensive element, the girder. In fact, instead of erecting costly bridges to be used perhaps but a few minutes in the twenty-four hours, the Pioneer practically carries her bridges (all but the piers) along with her.

4. It is necessary in Africa and such places; to spin attenuated lines of communication, and avoid concentration and centralisation: for the amount of the tariff (and dividend) obtainable, depends entirely *upon the difference of market-value of the goods at the two extremities of the line;* an amount which increases out of all proportion as the distance is longer. This vital advantage will not only be nullified, but positively rendered antagonistic, if the carrying capacity of the line exceeds *existing* demands for transport.

Commander Cameron informed me that the value of cotton goods at Unyanyembé was about *fourfold* Zanzibar (coast) prices, although the distance was only 250 miles. There is therefore ample margin for a magnificent dividend, provided the market is not swamped by a *big* railway, of the old type. (See foot-note † on page 21.)

I am indebted to Mr. Prince, a merchant of South Africa, an ex-member of the local Parliament, and to Mr. Reginald Statham of Maritzburg, for statistics from which I find that the first narrow-gauge single-line railways at the Cape have cost 8000*l.* per mile: but that by reason of their short length and serpentine nature * they cannot earn a dividend or even compete with the ox-waggons which trade to the Diamond Fields, some 500 miles into the interior; although the railway charges average 1*s.*† per ton per mile for freight. (See Grover's Report, ¶ *e.* page 64.)

This fact alone proves that the Cape lines are twelvefold too large; for 1*d.* per ton per mile should pay well for transport, if you can only get enough.

2*s.* 6*d.* per ton per mile is the ordinary tariff for ox-waggons; the

* Here for the first time the Durban Maritzburg railway strikes the road, in the vicinity of which it remains with more or less tortuousness during the rest of its career. The engineering troubles of planning even a narrow-gauge line through such a country must have been serious, and the curves and gradients must be seen to be believed.—*Daily News.*

† Neither high rates nor a dividend are admissible on a State railway. The necessary return being more readily obtainable, indirectly, in the form of augmented revenue due to increased production resultant from cheap transport. The East Indian State Railway, however, offers the working Company a share in excess profits—a premium on high rates.

supply of which being less than the demand, enables them to obtain this very high rate; which, however, owing to loss of live stock from drought,* &c., hardly pays *them;* but would yield the Pioneer a dividend of about 70 per cent.: these rates have now risen to 8*s.* or 9*s.*, so that a Pioneer railway to the front would repay its outlay in a few months, especially as it must traverse the splendid Dundee coal-fields.

5. The working expenses of a line are more important than even their first cost; for even an overgrown line, economically worked, will pay at some remote period; while so-called cheap and light lines (as lately constructed in Turkey, Australia, and elsewhere) can never pay at all, owing to excessive meandering about to avoid trifling physical difficulties; to endless repairs consequent on scamped construction: and to high through transport rates, due to the exaggerated length of the lines in question. *In ordinary railways, where weight is power, the working expenses increase, as the scale decreases;* so that the use of *light* railways is the reverse of economical. (See Table on next page; and Grover's Report, ¶ *d.* p. 64, and ¶ *g.g.* p. 65.)

The Pioneer is not cheap in the light railway sense, for all its materials are of the most solid and durable description; while its working expenses are low, owing to the abolition of dead weight, and to the fact that the road will take care of itself. Its route also is always direct. Though temporary in structure, unlike make-shifts in general, its working is ultra-perfectioned. The Pioneer pushes its way to even the village door, the value of which may be conceived when the cost of collecting and delivering goods for transit between Manchester and London (180 miles) costs 8*s.*, or $\frac{1}{3}$rd of the total charge per ton for carriage between the two cities, equivalent to a railway carriage of 60 miles additional.†

I may mention for the benefit of my non-technical hearers, who may naturally think that, on plains at any rate, it is possible to lay

* The Bishop of Pretoria.—The "track" journey of 460 miles from the coast was a very trying one, an excess of drought depriving the oxen of food *en route*, and the outbreak of war occasioning such difficulties of transport that for two months the whole party had to live in tents. Of the oxen, half had died from lack of food and disease on the road. The health of the party was good. Since leaving Maritzburg they had been quite cut off from civilisation. "Three months' dust," says the Bishop, "sun, dirt, cold, drought, barrenness, thunder and lightning, hail like eggs, and yet only halfway."—*Daily Telegraph.*

See also the Daily Press for Lord Chelmsford's remarks on the difficulty of transport, a burden which no general of a *civilised* (?) army ought to be called upon to support. In Afghanistan the 'Times' correspondent refers to the deplorable loss of British animals and its consequent effect on our outlying provinces. Of 103 laden bullocks, performing easy 10-mile stages, only 57 reached their destination.

† Commercial Geography does not measure distances by the mile.

down portable railways on the unprepared ground; that in tropical countries the plains are generally converted into swamps in the rainy season, so that engineers usually construct a bank of at least 5 feet high in such situations, plentifully sprinkled with culverts; but even then the line is not secure. A remarkable instance of this was afforded at the Kilburn Agricultural Show, 1879, where the engine was nonplussed by the rails sinking below the ground surface, and such a trifle as persons scraping their clayed boots on the rails and making them slippery. (See Mr. Grover's Report, ¶ *i.* page 65.)

Abstract Value of various types of Railway Construction over the same line of country.

Cost per mile no criterion of value. See "Indian Break of Gauge," page 57.

	Gives or	Gives or
1. First-class railways .. A fixed quantum of earthworks.*	= Good grades, and tolerably direct route.	= Light rails and rolling stock, and fair paying load.
2. Light, cheap (?) railways Inadequate earthworks.	= Bad grades, and circuitous route.	= Heavy rolling stock, and serious amount of dead weight.
3. Steam Tramways on country roads No earthworks.	= Very bad grades, which cannot be modified.	= Extravagance in power and minimum of equivalent load.
†4. Fell's system Earth cuttings, but timber viaducts in lieu of banks.	= Very lofty viaducts, bad grades, and circuitous route.	= Unremunerative load, since being on a continuous viaduct, must be used with exceptionally light rolling stock.
5. Pioneer No earthworks.	= Surface line, *i.e.*, bad grades over rough country. Route, as the crow flies.	= Light rails and rolling stock, but very good paying load. (Compare with No. 1).

The ground too, in such situations, is soft, so that settlement would constantly occur; and with any *two*-railed system of railway, derailment is certain, if one rail should sink barely an inch lower

* George Stephenson, its inventor, fixed the limit of traction by gravity at 1 in 300 for an iron rail; to obtain which an unreducible quantity of earthwork is obligatory: but if to get rid of this expense we cut down the earthworks and use steeper grades, then we must seek, as in the Pioneer, some other motor than concentrated gravity. With the Pioneer, however, where *all* the wheels are coupled, the economical maximum grade is 1 in 7. So *it* can always command a choice of route, which no other system of railway possibly can do. (See Mr. Grover's Report, ¶ *h.* page 65.)

† At Aldershot Mr. Fell's locomotive could only take a nett load of 14 tons up 1 in 50, although the grades were improved to the utmost by a 5-foot cutting and a 20-foot viaduct. He admits that his system is, as regards grades, 50 per cent. worse than one on the ground, so *cui bono?*—*See* '*Society of Arts Journal.*' May 3rd, 1879.

than the other: and the narrower the gauge the greater the danger: * so that it is only where *one* rail is used that the road may be left to take care of itself, for a foot of settlement even would not endanger the safety of the train. Such two-rail portable railways cannot moreover be laid down upon curves without endless fitting, cutting the rails, &c. &c., as was found to our cost in the Abyssinian campaign.

Ballasting in tropical countries becomes quite a science, and forms one of the most costly items of maintenance. The Pioneer eschews it.

The Pioneer system of driving is antagonistic to impetus. It may be described as continuous; since every wheel of the train is as it were coupled, and the load is self-propelled and offers no resistance as in a load *drawn* up an incline. In fact vitality is introduced into each articulation, as an antidote to the usual dead load. Hence a Pioneer train may also with safety run fast down inclines which an ordinary railway could not face (see Grover's Report, ¶ *h.* page 65): consequently over rough country the Pioneer could carry mails, &c., quicker than a first-class railway.† The brakes, which are merely the motor reversed, are continuous also, and so arranged as to lock all the wheels in the event of accident. The main feature is that the brakes are always *on*, and require a constant but trifling application of extraneous force, to free the wheels: thus even the absence or neglect of the driver, is instantly revealed by the blocking of the whole train, consequent upon the brakes returning to their normal state—fixed. A small boiler is also made to do the duty of a large one, by employing a differential arrangement somewhat similar in effect to the Bramah press; while any minor inequalities of loading throughout the train, are corrected by a water balance on the engine, under the control of the driver.

6. A Pioneer (weak) *double* line can carry considerably more than a (strong) *single* line of the 4·8½ gauge. Collisions and derailments are impossible, and no necessity exists for the use of any of the 60,000 signals which a director of one of our main railways lately stated his Company daily used. While as traffic

* Accident to the Flying Scotchman.—The Flying Scotchman ran off the line between Ranskell and Bawtry, on the Great Northern Railway, about 4 P.M. on February 14, 1879. The rails and sleepers on the down line were torn up, and traffic delayed for some time. Several passengers are reported severely maimed or bruised, but none are known to be fatally injured. Breakdown gangs from Doncaster and Retford were promptly on the spot, and, under the superintendence of the district engineer, quickly cleared the line and replaced the metals. *The accident was owing to the subsidence of the permanent way, caused by the recent thaw.—Daily Telegraph.*

† On the basis, of the value of rapid transmission of news. The Pioneer would, in the Euphrates valley, form the missing link between the Railway and the Telegraph; and charge accordingly.

increased, a third and fourth line could be laid; so that the quick traffic might be separated from the slow, goods from passengers, &c.; and the railway worked to the full extent without any augmentation of risk: one line would be, however, reserved as an endless siding, on which the train might stop anywhere to pick up the freight boxes, a necessity in agricultural countries where produce is bulky, stations few and far between, and feeding roads not in existence. Thus the latest English *principles* can be adopted at the very outset, since we have, engineeringly speaking, virgin soil to work upon; but the method employed for carrying them out must be utterly different.

6A. The Pioneer skeleton train is never disintegrated; for the freight being in boxes, is treated like passengers: hence full trains can always be assured, and the usual confusion and waste (over 80 per cent.) due to the waggons and goods playing hide and seek with each other in the crowded depôts, is entirely avoided. (See pages 44 and 45.)

The introduction of continuous brakes on ordinary railways, will ere long necessitate also the employment of connected or continuous goods trains; for passenger safety demands the use of continuous brakes quite as much on goods trains as on passenger; since as they both use the same track, they can run into each other with equal impartiality.

With such a margin of dead weight in its favour, the Pioneer eschews the bother and cost of weighing goods, the cubical capacity of the boxes being sufficiently approximate. (Shipping system.)

Like the coal waggons in this country, the boxes would often be owned by private individuals; but the endless worry experienced by companies repairing leased waggons of all sorts of types would be avoided; since all the working parts are the Pioneer Company's own property, and under their control.

7. Ordinary railway construction is tedious in the extreme; but the Pioneer capital can be turned over in a few months, and the line be opened and remunerative before the manufacturers' bills become due. Hence a small working capital will go a long way.

On the Suez Canal, where over 90 per cent. of the outlay was for earthworks; actually one-half of the capital was spent in paying interest during construction.

8. The rate of progress of erection of the Pioneer is at least one mile per diem per 100 trained men.* The train brings up the whole of the materials, which as they arrive, are seriatim laid and fixed in complete working order at one operation. On the grand

* The portion erected by the Grenadier Guards at Whitehall in the presence of Sir Garnet Wolseley gave even better results.

principle adopted by the Pioneer of disturbing nothing local, either natural or human; the assistants necessary would *not* be drawn from local sources:* so that the railway would appear almost as if by enchantment, and without allowing time for intrigues, or exciting that suspicion of conquest and possession, which walls-of-China-like masonry and earthworks would be certain to engender.

In the frontispiece the Pioneer road is shown made of timber. Such a road in South Russia was contracted for at 400*l.* per verst, or 650*l.* per mile, in oak, fixed complete. I would invite particular attention to the scale of the structure; it is only one yard high, which it rarely exceeds, and the train partakes more of the nature and size of a donkey and panniers, or a camel-caravan, than of a Pullman car. The rail used may be of iron; but owing to a special arrangement of the running load by which the weight is entirely supported by the posts, *and never bears upon the span;* bamboos, poles, or planks, answer the purpose equally well. The train becomes in fact a *short* travelling girder, and thus eliminates this prohibitively costly element (the girder) from the endless viaduct which constitutes the Pioneer permanent way.

Old rails will serve admirably for the Pioneer. If of the Vignoles pattern, they should be turned upside down and used T fashion: when double-headed, they should be employed on their sides, as a grooved rail.

Old rails do not pay to re-import; so are practically valueless in the interior of continents, although intrinsically they have suffered very little deterioration.

In Central Africa we should, however, use iron in lieu of wood, owing to the white ant; and also for commercial reasons: since iron is an English staple, and deferred payments over seven years can be obtained for a road entirely of this material.† The carrying-value of the line (second-class type) would not be less than 400 tons daily; for which an eminent Glasgow firm tender at 750*l.* per mile f.o.b. This is the smallest practical size made, and this even is too big for the occasion: but for horse traction the same may be obtained complete for 400*l.* per mile.

The makers guarantee the Pioneer Engines to take a nett load of 100 tons over grades of 1 in 10, at an average speed throughout of 10 miles an hour;‡ which would constitute a highly satisfactory train-load in respect to economical working expenses. The Pioneer,

* Common Kaffir labourers have been paid as much as £1 per diem, in the interior.

† It would be more in accordance with sound commercial principles if we exported ready-made railways instead of the money to make them with.

‡ An ordinary engine of like weight, as used by Mr. Fell at Aldershot, would only draw 4 tons under similar conditions.

therefore, can travel as the crow flies, and not being affected in price by ordinary physical difficulties, no surveys are required.

As land feeders to the Pioneer system, for no line of railway in large continents is worth anything without feeders; I suggest the single-rail tramway shown on page 5. This is worked by animals, where the "fly" permits, but by men in other districts. The cart is of wicker, covered with hide, and is waterproof, so as to take the water at river crossings; the pontoon collar affording sufficient flotation for men and cargo. Four men could transport easily on such a rough tram-road one ton, or about fiftyfold their present burdens; while by the introduction of the Indian native "tapaul" or post system, all the graphically drawn miseries entailed by deserting pagazi, &c. &c. (see Cameron), could easily be avoided. The cost would be about 50*l.* per mile under favourable circumstances. It may be also used without a rail or any preparation, on ground impracticable to two-wheeled vehicles; and if made of a size readily handled by two men, would be of invaluable service for active military operations, for carrying intrenching tools, ammunition, &c., acting as laagers, and forming a magazine for company squares to rally round—as suggested by Captain Geddes.

Ordinary carriage-roads are quite out of place in Africa. 1. Their maintenance in the dry season is impossible, since the materials will not cohere, and the vegetation breaks up the road-surface; while the wooden wheels of the vehicles are constantly coming to pieces. 2. It is against common sense also for a private company to level a wide track, unless the road is for common use with wheeled vehicles like a street, where hundreds of different interests have to be accommodated; but for vehicles under *one* organisation, a prepared surface of a few inches in width, offering easy traction, is far cheaper to make and keep in repair, than a very indifferent road necessarily many yards wide, offering a large target to the attacks of the elements. It possesses besides the advantage of allowing all the falling gradients to be worked by gravitation, the rises alone being worked by power, either animal or mechanical; be it wind, water, or steam. The up-line would follow one line of country, and the down-line another, so as to make the maximum use of gravitation in both directions. For military purposes no waggons are used, the cases themselves being attached to a yoke and wheel on a system analogous to the timber lorries of this country; hence for a rapid expedition where time necessitated the employment of only a single line, there need be no return empties or necessity for either a double line or turn-outs. The cases possess sufficient flotation for crossing streams or for floating ashore when discharged over a ship's side. The construction materials are also

tied up into self-supporting bundles fitted with temporary wheels; so that the laying of the road is continuously forward.

Captain Burton assured me that in his opinion the origin of the slave-trade was due to the absence of beasts of burden or other means of transport. Since, however, animals do not thrive; mechanical means afford the only chance we have of extirpating the slave-trade. But neither the construction of roads with a view to steam-traction, nor of earthwork railways, are admissible; since in addition to other objections, they would but afford a pretext for forced labour, the greater portion of the work being local.* Elephants are commercially out of the question except for exploring purposes; their keep being prohibitively costly. (See "Elephants for Africa," p. 58.)

On the Congo side of the continent, about 150 miles of Pioneer road, erected at the Yellala rapids, to ply in conjunction with steam-launches above and below the cataracts; would open up say 50,000 square miles of country at the least. The cost would not exceed 180,000*l.*; and if the trade were properly conducted, *i.e. as a transport monopoly, and the goods only of the Company were transported to the exclusion of everybody else's;* judging from Asiatic experience, I fancy the earnings would not stop at cent. per cent.† *But such a*

* H.M. the King of the Belgians thought the only difficulty Mr. Haddan had not met was the financial one—of a subsidy to induce capital into an unknown country. Mr. Haddan replied he had done even that.—*See* "The King of the Belgians," p. 57.

Captain Burton writes, with reference to the Pioneer: "That by its means the mineral wealth of the land of Midian might be rendered immediately profitable."

Commander Cameron thought that with special steamers and the Pioneer railroad, communication might be opened up through the Nile, the Congo, and the Zambesi, into the very heart of Africa.

Mr. Stanley suggested that Mr. Haddan should get a number of English capitalists to form an East African Company similar to the old East Indian Company.

Mr. William Ridley, the chief engineer for Natal, strongly recommends the Pioneer for feeders; while General the Hon. H. Clifford has recommended it for the Cape War.

Gordon Pacha hopes "ere long to use it." Lord Napier of Magdala, Sir Garnet Wolseley, *see* Military Railways, p. 54, Sir Samuel Baker, Sir Henry Green, General Vaughan, &c. &c., *see* p. 52, warmly sympathise with the author's aims.

For a detailed description of the system, see the 'Times,' January 6th, 1875; the 'Society of Arts' Journal,' April 6th, 1877; 'Iron,' March 17th, 1877; the 'Engineer' of January, 1870; the 'United Service Institution's Journal,' 1878; the 'Graphic,' August 3rd, 1878; the 'European Mail;' the 'African Times;' the 'Calcutta Englishman;' the 'Bombay Gazette;' the 'Mossul Bay Advertiser,' July 1879;' the 'Standard,' September 17th, 1879, &c., &c.

† Calculating 9*d.* per lb. as the average value of barter merchandise at Zanzibar, and 3*s.* per lb. at Unyanyembé (Cameron's estimate), we have 2*s.* 3*d.* per lb. margin for freight *and profit*, which amounts on this basis to 15*s.* per ton per mile = a dividend of 165 per cent. on a Pioneer *and trading* capital of 2000*l.*

private railway must be a dwarf to revel in excess, since if a giant it must either starve or share a miserable pittance with others. This I consider to be the key to the whole question, and English mechanical pride must stoop so as to conquer it, and give up all grand ideas of 50-ton locomotives and spacious saloon-carriages, for many a year in Central Africa; since the present traffic is under 20 tons per diem upon the most frequented line of route: a quantity insufficient to nourish any road or railway worked simply as a transport agency, as in England. (See Ready Reckoner, p. 23.)

On the east side the area of country opened per mile of railway would not be so great; but as trade arteries already exist, they warrant the greater outlay which a longer railway would require.* Of the comparative suitability of the various routes to railway purposes, it is not necessary to give any opinion, since the Pioneer is independent of physical details; but there seems to be ample traffic on them all, from the southermost Zambesi route to the northern Dana one.

At the Cape—a Pioneer line from Maritzburg to Pretoria would in the opinion of local authorities, not only effectually end the war and compensate *in kind* for the enormous losses of transport animals; but worked in combination with a lease of the Government coal-fields, would prove a most profitable speculation.

I will conclude this Paper with the hope that, ere more valuable lives are lost in pushing explorations further, the base of operations may be by means of such a railway as the Pioneer, so far advanced into the interior, that explorers may not be worn out before they can reach new ground.

per mile. The *existing* annual traffic is estimated at 6000 tons (of a value of 500,000*l.*), or in round numbers 20 tons per working day. This would entail running only one train each way every alternate day, at a cost of 1*s.* per ton per mile, reducible to 1*d.* when the line is worked to its full capacity of 100 tons daily in each direction. Mr. Hutchinson estimates the bare freight at 70 per cent. of the value of the goods transported = to 4*s.* per ton per mile for carriers' charges, while the merchants' profits amount to nearly three times as much, viz., to 11*s.* per ton per mile. The advantages therefore of using the Pioneer as *a trade weapon*, and not simply as a carrier, may be valued at 130 per cent. These calculations are for a line from the coast near Zanzibar to Unyanyembé, at which place the line would bifurcate to Lakes Tanganika and Nyanza, a total length of 700 miles. The trading and railway capital required to make the line piecemeal would not exceed 200,000*l.*, including all necessary block-houses, stores, &c.; but if a large capital were available, the whole country could be simultaneously treated, with more than correspondingly inceased results.

* The Sultan of Zanzibar, it is said, offers a subsidy of £100,000 towards the construction of the first railway in Central Africa.

READY RECKONER.

For ascertaining the Amount of Traffic required to earn 5 per cent. on any required Capital, at a charge of less than 1d. per ton per mile.

Divide the estimated cost per mile by 13, which will give the required tonnage (up + down).

Ex.:

In Iron.

Narrow Gauge — 13) £8000 = cost per mile.
620 tons of traffic.

Pioneer (1st class) — 13) £1300 = cost per mile.
100 tons, or $\frac{1}{6}$ the average carrying power of the system (single line).

Pioneer (2nd class) — 13) £750 = cost per mile.
58 tons per diem.

Pioneer {animal / traction} — 13) £390 = cost per mile.
30 tons per diem.

The basis on which the above rule was established was ascertained from Mr. Juland Danvers' admirable statistics on the nine principal Indian railways (1877, 1878).

These lines have a mileage of 6500, and cost £15,000 per mile. The average tonnage of goods carried was 1440 tons daily both ways.

The capital therefore expended was £13 per ton transported (the divisor used in the formula).

The tonnage above mentioned includes passengers, calculated at 2½ to the ton, the transport of 2½ passengers *costing* the same as 1 ton of goods.

The average tariff charged per ton for passengers and goods = ·88*d.*

The average cost of transport per ton for passengers and goods = ·35*d.*

The chief merit of Mr. Juland Danvers' returns are their straightforwardness. He is alone in publishing the cost of the real work done, *i.e.* the cost per ton (carried one) mile: while the European companies without exception, affect comparisons on the positively misleading basis of the cost per *train* mile, irrespective of the amount of freight each train carries.

Thus badly filled trains show a cheap train mileage cost, indicative in reality of anything but economy. Ex.:

On the Paris Steam Tramways of which I was manager; our horse opponents by running four times the requisite accommodation, obtained a complete victory on the *train* mile basis, but were ignominiously defeated on the *ton* mile system.

	Working expenses per train mile.	Nett freight per train mile.	Cost per ton mile.
Steam	7·43*d.*	3·5	2·12*d.*
Horses	6·40*d.*	0·9	7·10*d.*

Mr. Price Williams and Mr. Condor have done good service in support of the "ton mile."

NOTE.—Indian rates are *low* as compared (in money) with those of Europe: but prohibitively high as regards their percentage on the intrinsic value of the articles transported in the two cases. The tariff, and on a sliding scale, is of great political importance; transport being a tax (either export or import at will) in all but the name, and average through rates in many cases prohibitive. Bismarck has noted this, in the Prusso-Austrian treaty of 1879.

THE PIONEER RAILWAY *v.* IRRIGATION AS A PREVENTIVE FOR INDIAN FAMINES.

AT the Society of Arts, in the discussion of an exhaustive paper on Indian Famines, by W. T. THORNTON, Esq., C.B., Mr. Haddan contributed the following :—

Mr. HADDAN said he wished to point out that the question of famine was entirely one of intercommunication, for he had seen in Turkey famine rampant within 100 miles of a spot where the crops were rotting on the ground.* Irrigation had been spoken of as a *preventive* of famine, but in the district to which he referred the irrigation was simply perfect. The country had suffered for two or three years from drought, and the subsequent year produced a magnificent crop; but it could not be exported, and the consequence was that many persons were ruined, because, owing to the former bad years, they had had to borrow grain for sowing purposes at such an exorbitant interest that they could not repay the debt, owing to the small margin of profit derived from glut prices. Had there been a market, a good crop would have been a blessing instead of being, as it was, a curse. Therefore he thought that proved that irrigation had nothing whatever to do with the question. Nor could he see how an element so irregular in supply as rain-water, could possibly offer itself as a guarantee against famine. A money insurance is equally inadmissible, *as a means of prevention.* With a teeming population of 210 persons to the square mile, the food supply should not be expected to be producible locally; but must be partially derived from extraneous sources. The old system of State grain stores answered well, it has how-

* "The drought before which these sons of the Desert are fleeing, has naturally produced a great rise in the price of grain and nearly all articles of food throughout the southern and eastern part of the Pashalic; prices even in Aintab are double what they were a year ago, and nearly treble what they were three years ago; to the south and east of us the difference is much greater.

"On the other hand we hear that 100 miles to the north of us the harvests have been abundant and grain is cheap. The expense of transport, however, is so great that one part of the country may be suffering from famine while another part can with difficulty dispose of its surplus yield.

"Without a better system of roads in Turkey there can be no permanent prosperity."—*Aintab Correspondent to the* 'Times,' October 11th, 1879.

The population of this part of Turkey is only 23 to the square mile.

ever been abandoned in India as uncommercial, and nothing substituted.

When the natural divisions of countries are overcome by a complete system of means of communication, then, but not till then, can the varying fortunes inherent to agriculture be equalised. A scarcity in one province would, in lieu of disaster, positively contribute wealth to its neighbour; and Western principle, as to supply and demand, would then enjoy full swing, and famines might safely be left to take care of themselves.

Now, irrigation is almost always so purely a local matter, that its use or abuse cannot fairly be considered an imperial question affecting the condition of the Empire: while intercommunication, which water may it is true contribute to, but cannot completely afford, is both commercially and strategically a State necessity.

Moreover, in isolated provinces where export is impossible, a good harvest, after a series of bad ones, is I have found from experience, a curse to the country in question; since prices fall, and the ryot cannot pay either his money taxes, or the high rate of interest due to the shroff or native banker for borrowed capital. To such an one irrigation charges would be a mockery.

In Turkey, notwithstanding all the irrigation works (which have mostly been preserved), famine may be said to be chronic The prices of produce vary in different provinces as much as 1000 per cent., and crops may be seen rotting within a paltry hundred miles or so of patiently endured semi-starvation. The introduction of fragmentary railways has drawn the caravan beasts to the coasts, and so increased the evil; and in the interior, except during the short pasture-season, animal transport of bulky agricultural produce is for long distances out of the question, since the animal must carry his own food-supply also.* The roads, too, are frequently impassable just after harvest time, more especially in the black soil districts. A means of getting to market is really what is wanted. *Under present circumstances* irrigation would but increase the evil by augmenting the cost of production, while in but rare cases could it yield a *quid pro quo* in the shape of providing an outlet for export, owing to the nature of the country being unsuitable to the construction of canals.

Now railways, as we understand them, are too costly; and, what is more, require too much animal labour for their construction; labour, moreover, expended in a form only indirectly and tardily

* The preparations for the Afghan campaign have shown the difficulty of obtaining *animal* transport to order. The permanent injury done to local trade by the temporary withdrawal of 60,000 animals from circulation, may be better imagined than described. A famine might result.

profitable, and therefore not to be compared, from an economist point of view, to the same labour spent in tilling the ground or in the arts. Their construction is slow, invariably deranges the labour market, and the working and administration far too complicated and costly for general transport purposes in out-of-the-way districts. Their influence is also too concentrated for an agricultural country; for, owing to the small value but great bulk and weight of its products, it does not pay to cart any great distance to a railway: nor is animal transport even practicable at all seasons, especially just after harvest, when the monsoon cuts off whole provinces from trade communication with the outer world. Thus the supply of traffic is not regular, and one of the first principles of transport economy are wanting.

In countries like India, where interest on capital is so high, and every native is more or less a pawnbroker, not satisfied with less than 20 per cent.; the rapid means of realisation of capital offered by the Pioneer is the only way to promote native investments.

We have the proof of this in the fact that our colossal 5 per cent. guaranteed railways have been made almost exclusively with British capital; want of native confidence has nothing to do with the question, the inducements were simply not sufficient.

Now, for ten years past, I have studied the question of supplying vast continents with remunerative railways (in the Eastern 20 per cent. sense), and I am at last able to offer a system resembling the spider's web, whose fine yet strong lines can be rapidly spun at small expense all over the largest areas, and with marvellous rapidity; simply because, 1st, there are no earthworks, and 2nd, because almost the whole of the work can be performed in the workshops of the world, while but a fraction need be executed *in sitú*.

A full description of this Pioneer railway system was given lately in this hall, so I need not give details; but the cost in iron, on a scale suitable to Madras, is 1000*l.* per mile in working order, the carrying power 200 tons per diem each way, the progress of construction at the rate of one mile per diem from each starting-place, and the tariff $\frac{3}{4}d.$ per mile to pay 20 per cent. dividend.

These lines would, doubtless, in a few years be too small for their purpose; but therein lies the certainty of a good and immediate dividend, and the non-requirement of Government guarantees or subsidies. Extension is possible at few months' notice; but double lines need not necessarily be laid side by side, but many a mile apart, and only touch at the termini, so as to make their influence as wide spread as possible.

THE PIONEER AS A SOLUTION OF THE CANADIAN PACIFIC RAILWAY QUESTION.

In the discussion following the reading of the paper, "Canada and and its vast Undeveloped Interior," by SANDFORD FLEMING, C.M.G., chief Canadian Government Engineer:—

Mr. HADDAN said: I believe a railway across from the Pacific to the Atlantic Ocean is contemplated because its construction forms one of the conditions by which British Columbia was induced to join the Canadian Confederation. To keep faith a railway of some sort must consequently be made, whether it will pay or not. Both the author and Captain French have told you that as yet all the districts to be traversed by the proposed railway are not even surveyed, and that the country is of the roughest description, and in many districts quite barren. The climate also is so inhospitable that over eighty of the explorers have died from exposure. I fancy therefore it will be difficult to induce capitalists to invest in such a speculation, especially as not a week since Mr. Fawcett, M.P., demonstrated that even Indian State Railways had not returned 1 per cent. interest on the capital expended. The picture on the wall represents a view of the Pioneer, a structure made entirely of timber, and employing no earthworks or masonry of any description. Its construction requires 4500 cubic feet of rough hewn timber per mile, and its cost in Canada would not exceed 600*l.* per mile; while in twenty months the whole line from ocean to ocean could be erected; as it can readily be put up at the rate of two miles daily, with a force of only 200 trained men. Railways as we understand them in England are permanent structures, and therefore not suited for a tentative line like the Interoceanic Railway which is projected across a district whose trade centres, are yet unformed: *for an earthwork railway once made cannot be altered.*

Moreover, a narrow-gauge line cannot be turned into a broad gauge; nor, as suggested by the author, can "territorial" roads be constructed with the view to their conversion later on into rail-

ways, since carriage-roads take a much more direct route than railways can possibly follow, and were they circuitously traced like railways are, would simply never be used.* The Pioneer or steam caravan has but one rail, elevated on stout posts at about 3 feet above the ground; the carriages or panniers ride astride the structure and do not touch the ground, which is therefore left intact; thus, the inequalities of the soil are quietly ignored, instead of being overcome at great cost. Nature resents the radical interference with its features which earthworks cause; therefore as a first step in natural economy the Pioneer avoids them altogether—no small advantage in a country where labour is wanted for better things. People laugh at the appearance of the steam caravan, because they are not accustomed to it, but what can be more calculated to provoke derision than the abstract principles of our European system of railways; where to obtain a few inches of smooth road to run upon (in all about 10 inches for a double line), engineers deem it a *sine quâ non* that a width of 40 or 50 feet of ground should be levelled? The Pioneer, by using one rail to run upon, need not level the ground at all, either transversely or longitudinally; which therefore is the most sensible?

Again, ordinary locomotives demand weight as a means of obtaining pulling power, and the steeper the line the heavier the machine our engineers say they require. The principle involved being only correct on the level, and therefore not applicable to railways. Ex.—On the Crystal Palace Line of the Chatham and Dover Railway, a purely passenger line, the engines actually weigh 50 tons; and the rails and bridges throughout have of course to be made to support this leviathan. The unit to be carried is *one* passenger, but the scale adopted demands a unit of 60 passengers, so that it is impossible to cut one's coat according to one's cloth. The Pioneer, however, supplies a mechanical or traction unit, equal to, but never in excess of, the commercial or traffic unit of the country catered for. The Pioneer engine abolishes the necessity of using concentrated weight for obtaining pulling power. Thus it can climb a mountain side and go as the crow flies, taking behind it moreover a train of 60 tons nett freight; while over such country an ordinary train would have become all engine and brake van. Mr. Fleming insists very properly on cheap working expenses as meaning more in the long run than low first cost; and it is precisely by abolishing weight as

* Ex.—Pack horses never traverse a carriage road throughout, but cut off all the bends, &c., its grades being too easy for their climbing powers.

tractive power that the Pioneer, although it is cheap, can carry goods at about half the cost of the ordinary railway.

While resident in Turkey (some ten years) I had almost daily the problem to solve—of how to make a railway in no time, without any money to speak of; and yet everything to be strong and substantial and nothing scamped; and it was this training which has enabled me to come down from our high estate of saloon carriages and Pullman cars, to devise a system of steam caravan suited to the pockets and requirements of poor or vast continents, which in the usual course of events might otherwise never see a railway at all. Surely in such countries, especially after a war or famine, it is not at all profitable to waste the energies of men in cutting off the tops of mountains and filling the valleys with them; especially as the more rugged the country is, the fewer the population locally available for the work. It is surely also unwise to advocate "earthwork railways" in Canada, where navvies are rare but timber a drug, or to employ cattle for dragging carts over roads, which if ever made cannot even be kept in order for want of hands; since Mr. Fleming states there are but 30,000 settlers along the whole line of 1500 miles. Machines by the score have been invented to save some detail of labour; but the Pioneer saves both man and beast the drudgery of digging and porterage, and sets them free to do their duty as colonists, and so develope Canada into "the granary for the mother country," its proper mission. Huge earthwork railways, moreover, *concentrate* the animal power of the country during their construction, and the mercantile community is also attracted afterwards; in defiance of the fact that successful colonisation requires diametrically opposite treatment, and must consequently be retarded instead of advanced by such injudicious action.

I will conclude with the following hint to Colonial Railway Shareholders: English railway management is confined to carrying merchandise, there being nearly always sufficient quantity to constitute a specialité; but in the colonies this is not the case: and consequently extraneous means of making a dividend may be legitimately employed. In other words, a manager should combine both a merchant's and a carrier's trade, like many a ship-owner does.

ON COMMUNICATIONS WITH BRITISH INDIA UNDER POSSIBLE CONTINGENCIES.

By Major-Gen. Sir F. J. GOLDSMID, C.B., K.C.S.I.

In the discussion on a Paper, read at the United Service Institution, on 'Communications with British India under possible Contingencies,' Mr. Haddan said:—

I was late Engineer-in-Chief to the Turkish Government. The province which I had under my charge for eight years was bounded on the north by Aleppo and on the south by Jerusalem; and I think I can therefore give you a little information on the subject of the Overland Railway to India. I am sure you all will agree with me that Sir E. Goldsmid's suggestion of the Island of Cyprus, as an outpost, is a golden one, for you will see that it is quite as easy to get to it by water as it is to Constantinople, the proposed terminus of the Austrian State Railway; or rather I should say, it is quite as near, and decidedly much easier. The line from Vienna to Constantinople would have to pass through Bosnia, in which country there is not a flat ten-acre field to be found; so that I think the question of a through European line may for some ten or twelve years be decidedly thrown on one side, and Constantinople be ignored. The only chance, therefore, we have in our time of getting to India by rail is decidedly from the Mediterranean. From Smyrna, viâ Cassaba, if intended to open up Asia Minor: and from Iskenderun, if India alone is our object. With all due deference to Mr. Palgrave, I may mention that the Beilan Pass is so close to Alexandretta that you cannot climb it by an ordinary railway. It is 2200 feet above the sea-level, and situated at a distance of only 14 miles from the coast, consequently the gradients for a railway would be 1 in 12, so that it would be another financial failure like the Mont Cenis, and without the ready-made road either. The question of the insalubrity of Alexandretta has been much exaggerated. During my period of office there I was instructed to drain the marshes. The whole thing could be done for 3000*l*., which is a mere bagatelle. The plans were published in

the Blue Book on the Euphrates Valley Railway. In fact, it is not a marsh at all, the bottom being sand; but the sea, beating into the bay, has formed a sand ridge all along the littoral, which prevents the fresh water escaping into the sea; moss and all sorts of vegetation has sprung up, and the fresh water not being allowed to run off, a very undesirable smell arises from putrefaction. All along the coast from Alexandretta to Suez, there is no port or harbour at all, except Alexandretta. The apology for a quay is situated close to the town, and on the east side of Alexandretta Bay; but there is a fine natural harbour on the west side of the bay, at Ayas.* Starting from Ayas, after the Plain of Issus is traversed, you can commence to rise many miles sooner than when starting from Alexandretta itself; you may thus get over the Beilan Pass, and you also *turn* the question of insalubrity. The port of Seleucia or Suedia has been suggested, because there is no pass to get over; but there is no harbour, and the river has to be crossed seventeen times in running up the valley. Moreover, between Seleucia and Alexandretta there is a famous point which is called Ras-el-Hanzir or the "Pig's Head," which is quite impassable even for foot passengers; so that it would be impossible to join *this* line to Europe. This is one of the main arguments in favour of Alexandretta as against Suedia, Tripoli, Tyre, and all the southern ports, and is the reason why the preference is given to Alexandretta in a commercial point of view. But I fancy Sir F. Goldsmid was not proposing the Palmyrene route as a commercial speculation but merely as a military line, and there is no objection to his route, provided arrangements be made to join the European main line route at Aleppo, or some point even further inland, say Mardin. If we study all the Lebanon passes from Alexandretta south, you will find (1) Suedia, the outlet of the Orontes; (2) Tripoli, which is only 700 feet high; (3) Tyre, which is the natural outlet of the country, there being no pass, the Leontes debouching there. Beyrout is out of the question, as the road to Damascus passes the Lebanon range at over 3000 feet elevation: it might have been turned, however, *viâ* Sidon. The learned lecturer referred to Baron Reuter's expedition to Teheran. The Shah of Persia was most anxious to have the work done under his own eye, and as he would not trouble to go to the Caspian end of the line, he insisted on the work being commenced at Teheran. The cost of the rails, owing to transport difficulties, I was informed by the engineer in charge of the line, reached such a point that they might have been made in silver on the spot. With reference to

* See Map, page 35.

the Suez Canal, I saw a letter in the 'Times' a week ago, signed MacKillop Pasha, in which he states that he has provided such powerful dredging machines in the event of a steamer or vessel being sunk in the Canal, that he could cut a fresh channel in a week. There is one very bad place I may mention, near Ismaila, where such an operation would be out of the question: it is a rock cutting—the Suez Canal is not all sand, by any means. This cutting is something like 70 feet deep, and it is, in addition, situated on a very sharp curve. Now, if any political accident happened to a vessel in the Suez Canal, it is quite certain that it would occur at this point; so that the route to India by the Suez Canal might be perfectly blocked at any moment and in the simplest manner possible. The Egyptian Railway would not mend the matter, for there would be no reserve shipping at Suez. The Canal being situated, say roughly, half way to India, an *equal* amount of shipping facilities would on an emergency be required on either side of the Canal. That this necessary equilibrium is far from being a fact, the obligatory use of a sailing vessel to transport a portion of the Indian Contingent to Malta affords sufficient proof.

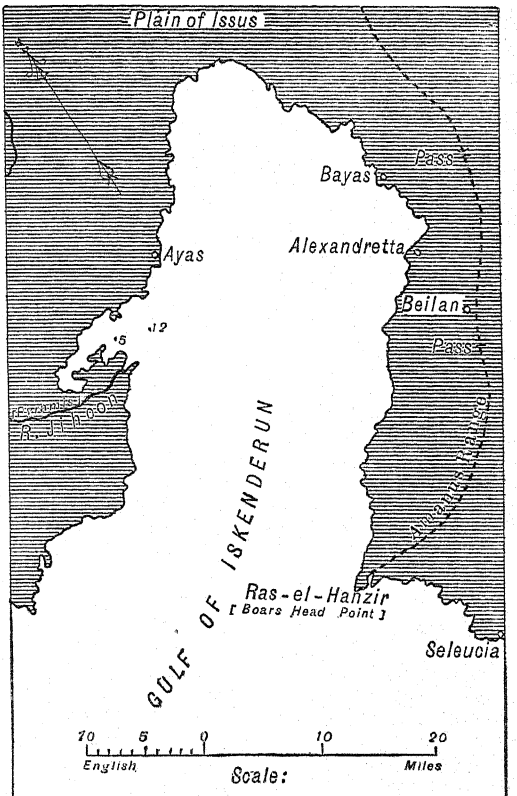
The value of the Euphrates Valley Railway is to be measured by the additional distance it moves the final point of transhipment nearer to India; since from Grain to Kurachee the few ships available in Indian seas can by repeated short journeys do as much duty as the larger supply in the Mediterranean. Speed is not important in a military sense, as it only anticipates the *first* delivery. A regular supply, however slow, is what is required. This is the only solid argument which can be used in favour of an overland line to India, but I have never heard it advanced by any one before.

You may wonder why one could not make a line from Alexandretta to Meskineh, a town near Aleppo on the Euphrates, and thence adopt river transport. It is only about ten hours from Aleppo to Meskineh, or 180 miles from Alexandretta; but the Euphrates, as also the Tigris, is very tortuous and sluggish, and full of shoals. The height of the river at Meskineh is only 600 feet above the Persian Gulf, so the fall is not enough to cut a straight channel, and the consequent detours are so overwhelming that after hours you will come back almost to the spot where you started from. There are also weirs erected all along the river for irrigation purposes, the cost of buying up which precludes all idea of making the river navigable. Midhat Pasha cut openings through the weirs and made them into rapids. It nevertheless took nineteen days to

get from Baghdad to Meskineh. They had to stop at night and also frequently in the day to cut fuel, &c., and in bad places ran into sandbanks every five minutes. These seem trifles now when you are not in their midst, but on such an important route, such tedious and irksome delays would be fatal. The city of Aleppo is about 1100 feet above the level of the sea, and the line from Alexandretta, *viâ* Aleppo to the Euphrates, has nothing more to recommend it over the Palmyrene line except that most important point Mr. Palgrave mentioned to you, viz., the question of water, which is a most important one; but for a strategical line I believe Captain Burton's proposed line from Tyre is the best, as it runs at right angles to the Persian frontier and not parallel to it.* It has been surveyed by the Turkish Government, and water borings were attended in every case with success. The importance of this matter with reference to the road to India has not, I may mention, been overlooked by Russia. Seven years ago they appointed a Consul to Aleppo, whom I knew intimately; and without breaking confidence in any way, I may mention that this gentleman's whole business was to find out all he could about the Euphrates Valley Railway, and to place every possible obstacle in the way of its realisation. The English Consul at Aleppo mentions an obstacle to railway construction in those countries which, until I designed the Pioneer Railway some ten years ago, I found an insuperable one, and that is the question of labour. If you are going to make a railway of something like a thousand miles long, where are you to find the arms and the legs to make it with? In an agricultural country, especially after a war or famine, every man is better employed tilling the ground than in making unprofitable earthworks. In addition, a country like Turkey, where nearly the whole of the revenue is derived from agriculture, would certainly—the Consul thinks—be ruined during the six or seven years the bone and sinew of the Empire were doing the English Government's work instead of their own. I have studied this difficulty as an engineer, and have succeeded in devising a system of railway which has no earthworks. Its nature may be said to be a cross between the telegraph and the railway proper. It was described *in extenso* in this hall some ten days since, and can be executed at the rate of six miles a day with only 100 workmen per mile (foreigners). Being constructed entire in the workshop, its progress is unlimited,

* A line running *parallel* to a frontier can be so easily cut anywhere, that its defence is impracticable.

so that it could be laid down, not only from Alexandretta to the Persian Gulf, but, if you like, all the way to India in less than two years' time; and not require some ten or twenty years before a steam communication could be accomplished in the usual manner. The Peninsular and Oriental mail subvention would suffice to guarantee a 10 per cent. dividend for the "Pioneer," which, after aiding in the construction of its successor, and supplying reliable statistics of traffic, &c., would then be broken up into branches to feed the main line.



GULF

OF

ISKENDERUN,

SHOWING

RELATIVE POSITION

OF

AYAS BAY AND CYPRUS.



Stanfords Geogr. Estab. London.

TURKISH REFORMS:

THE DEVELOPMENT OF ASIA MINOR BY THE "ETAPPEN" SYSTEM.

"Decentralisation and the complete severance of Finance from the State; are Turkey's only chance of administrative reform."
(See also a Paper by the author on Turkish Resources, published in the Society of Arts 'Journal,' June 1879.)

In the discussion on a paper read by Mr. Hyde Clarke at the Society of Arts, December 11, 1878—

Mr. Haddan, ex-Ottoman Chief Engineer, said: Every one discussing this grand subject seems to forget that, since the signing of the Anglo-Turkish Convention, the Euphrates Valley Railway question has completely changed. It is no longer a vital point to connect England or Europe with India; but the question resolves itself into the establishment of a triangulatoral: of which Cyprus is the base, and Bayazid a town on the Russo-Turco-Perso frontier, and Grain a port on the Persian Gulf, would form the two apexes.

Any point south of the gulf of Iskenderun (the Syrian port for Cyprus) is shut out of this combination owing to the impractability of the Amanus Range spurs; so the question of the port becomes confined to Ayas. (See Map, p. 35.)

The real alternative value of the Euphrates Valley Railway in the event of the Canal being blocked, is to be measured by the additional distance it moves the final point of transhipment nearer to India; since from Grain to Kurachee the few ships available on the Indian side can by repeated short journeys do as much duty as the many and larger supply in the Mediterranean, and thus assure that *evenness* of supply which constitutes the first requirement of any transport service, military or civil. Speed is not important in a military sense, as it only anticipates the *first* delivery. This is one of the most solid arguments which can be used in favour of an overland line to India, though I have never heard it advanced by its promoters.

The lecturer has referred to the Pioneer system, which purposes,

for the same outlay as he contemplates and in far less time, to cover the country with a network of steam caravans in lieu of one trunk line. The Pioneer is in form and attributes a kind of cross between a railway proper and the telegraph: and being portable, it does not hamper the future with a makeshift but indelible gauge; a fatal mistake the lecturer, I am glad to see, has foreseen. My system requires no local labour for its construction, the whole being producible, and to any extent, in the iron foundries of the world: whereas the far greater portion of the Grand Trunk Railway in question must of course be performed locally, a work which would require no less than 50,000,000 days' labour to execute under unfavourable conditions; labour far better employed in tilling the land and creating produce for the iron Pioneer horse to carry to the European market to pay the bondholder with.*

In addition, no continental trunk line ever yet paid without branches.

Consul Skene gives his opinion that the construction of such a work would practically ruin the country by attraction of labour: the rural population being only about seven able-bodied men per square mile. Besides, where is the money to come from? The lecturer himself acknowledges that the long innings of the Railway Financier are over, as is also the vague notion that much local good is done by the mere spending of money in a foreign country. The money must be earned!—the starting capital being iron, in our control, and not gold, in theirs. What the Pioneer offers is an immediate 5 per cent. dividend: and in addition facilities of deferred payment, since the railway itself is available as security, the whole structure being of intrinsic value. The system moreover can be introduced to any desired extent without interference with the agricultural labour market.

India has given us ample warning of the evil attending the stereotyping of English Railways all over the world, in defiance of the well-known proverb to cut the coat according to the cloth (see page 62). Its Government refuses to guarantee any further lines *even within its own limits;* and with reason. The South Indian Railway, by no means a second-rate undertaking, for it is 600 miles in length, and cost £6500 a mile, carried last year (the famine year) only 162 tons of freight daily, or about one-tenth its full capacity. All chance of a dividend with such a limited traffic was impossible. Why, each ton carried one mile had to satisfy a capital equal to

* Mr. MacCoan in the December number of 'Fraser' has illustrated the difficulty of organising labour, Turkey having made only 600 miles of so-called carriage roads in twenty years.

£40. £13 being the amount of capital which one ton can earn a dividend of 5 per cent upon (see Ready Reckoner, page 23).

The South Indian, therefore, if it had been dependent upon goods alone, would have earned no dividend, but the number of passengers was so great as to add 300 tons to the daily total, and thus produce a dividend of $4\frac{1}{4}$ per cent. India has, however, a population of 210 to the square mile and Turkey in Asia only 23; and therefore we cannot hope in this case to count upon passengers for a dividend.

From statistics taken upon the most frequented route in Syria—viz. from Aleppo to Alexandretta—the existing traffic does not average 100 tons daily.* Whereas, to pay 5 per cent on a capital of £13,000 a mile (Telford Macneil's estimate), a daily traffic of 1000 tons is required (see Ready Reckoner, page 23).

Of course better figures may be produced by calculating on a higher tariff than the Indian; but a high tariff is indefensible, for it contracts the area of country available for export, while imports are handicapped thereby.

A low transport tariff, by promoting trade, raises very rapidly the local value of money, and enables larger import purchases to be made. A high tariff simply kills the goose which lays the golden eggs.

The Pioneer is intended to carry 400 tons daily, and was designed for this very route, and to meet all its special requirements: it is therefore ample for the present.

In Mr. Brassey's opinion, it would even do good service in saving time, and at least 30 per cent of the first cost, if it was employed as a forerunner of the great undertaking.

The local obstacles to railway enterprise in such countries are so serious, that no one intimate with their details would ever dare hope to see the work promptly carried out in the ordinary way, even with unlimited credit to support it.

Turkey wants a trade revolution to give it life—a rapid and striking one! Driblets of 30 miles of road a year will neither satisfy their political position nor their creditors. Its communications must progress by thousands of miles annually, and be *constructed entirely by extraneous effort:* for all its men, muscle and energy are wanted to remove the effects of the war, and to cultivate the soil. While we, *simultaneously*, can relieve trade depression at home by filling our workshops and foundries with work in supplying the iron roads so urgently required for carrying the Ottoman produce to market, and rendering their labour remunerative to both parties (see foot-note to page 25). Agriculture affords the most rapid known means of producing wealth with

* Mr. MacCoan's figures yield only fifty tons, at 2*s.* per ton per mile.

limited means, if it has a market. It has the merit, moreover, of not being in any way a novelty or a reform.

The further introduction of railways of any sort in Asia Minor or Syria, are, however, premature; until proper means have been taken to organise and make the most of the existing animal transport: since the Turkish lines already open have attracted an undue portion of the carrying-power of the Empire, to the detriment and ruin of some of the remote districts.

Animal transport is not a thing which may be left to take care of itself; it requires the most intimate fostering care, in the shape of an organisation capable of distributing the supply where it is most in demand; but above all, in establishing fodder dépôts, and taking certain precautions against famine and murrain, and in favour of rapid procreation. At present, in places where fodder is plentiful, an excess of animals can be obtained, while other districts are utterly denuded not only of means of transport, but even of animal power sufficient for cultivation. Caravans of camels and mules may be daily seen performing long journeys hither and thither, in useless search of freights, when the telegraph might have saved *them* the trouble and the nation the waste.

A semi-official company might with great advantage both to the bondholders and the State take over *on requisition* (not purchase) the whole of the animal transport. It would merely undertake as an intermediary the equilibrium of the supply and demand, but in an intelligent in lieu of the present haphazard style, and act as it were as transit-brokers, or like the "*Mukadums*" of India, who do the *head* work for their clans of porters, mule and camel drivers, &c., &c.

On the well-known principle adopted at a fire, by which the *chain* is formed—where the buckets are passed from hand to hand, and no fetching and carrying goes on—the animals would be confined to short beats, and the goods passed on from beat to beat. No inconvenience would arise from breaking bulk, because the animals are, of necessity, unladen every night. The "beats" would be carefully allotted, either to mules, camels, or carts, &c., as the nature of the country dictated. Each driver and animal would soon, therefore, be "well up" to the pleasures or otherwise of his own route; and would not be required to leave his home or run the gauntlet of variation of climate, risks of an unknown road, &c., &c., as the *through* transport trains are now doing in the Afghan campaign. The mortality from this cause is certain to be great; and, as fresh supplies cannot be made to order, famines of more or less gravity may result from this denudation of whole districts of their

only means of transport. It is reported that 60,000 camels have been already requisitioned for the use of the army in Afghanistan; while similar fears for the commercial future are rife at the Cape.

The Company would possess, however, the monopoly, so that no one but themselves could fetch or carry on the public highways.* They would introduce a fixed tariff from place to place, not necessarily established on mileage considerations alone; and thus give merchants the means of going largely into export operations, an impossibility now, since transport rates fluctuate 100 per cent during a season.

Their staff would be also available for improving means of communication generally, or establishing police control, or even for levying taxes in the form of transit-dues in lieu of *in situ*:† the system also would be available for our Government for supervising the internal economy of the country, since the organisation in question exerts its influence to the uttermost corners of the empire. They might freely do so in this sort of fashion, so well suited to the Turkish official mind, who will certainly resent and render abortive all open attempt at reform, or any direct interference on our part. We must not forget that Turkey cannot afford specialists. Men must be jack of all trades, traffic manager, banker, merchant, engineer, police magistrate, &c., all in one. The cost of such an administration would be more than covered, even if the rates were reduced (say one-half), a measure of the first necessity. All our more pretentious efforts are unfortunately looked upon by nearly all classes as the first attempts at foreclosure on the part of the sordid usurer, the English giaour; which unenviable character is all we have gained by lending, I might say giving, a few hundred millions or so to the Turks.

The grinding down of the peasantry by the Pachas, for their own purposes,‡ was all along sedulously imputed by them to the avarice of the European money-lender, whose Armenian prototype hardly a peasant has not a lamentable experience of, and whom

* Already given to the Damascus company on the road *they* constructed between Beyrout and that city, which though open sixteen years has never paid its shareholders.

† Thus getting rid of the tax-collecting curse and also its expense. The vicious system of tithe collecting is very graphically described in the 'Times' of October 18, 1879.

‡ The corvée or forced labour was one of the greatest sources of abuse; though even when properly conducted the result attained cost more for surveillance and tools than the work was worth. The loss to individuals was simply atrocious. I have known in my own district men travel from 10 days' distance to do their quantum of 8 days' road-making; these 28 days produced about 4 cubic metres of bank, value 2*s*.

they, naturally enough, class with us—as fellow Christians. Any innovations coming from us will be received with suspicion, if nothing worse, consequently a brilliant policy cannot be followed; but if the game is worth the candle, we must do the work in a semi-Turkish fashion. Leave the Padishah the honour and glory, but secure the solid advantages as a means of repaying our bond-holders by self-conducted trade, and not by financial hocus-pocus, or loans entrusted to others to spend. We should also have the merit of introducing order at the same time. *Any organisation possessing the monopoly of transport, in an Empire like Turkey; is more than financially speaking master of the situation.*

I will conclude with an extract from the 'Times' of January 6th, 1875:—"The doctrine that the only way to develope the resources of a country is to build railways, cannot be said to have died out yet; but it is scarcely so rampant now as it was a few years ago. Except for the support of the Government, even a richly productive, thickly-peopled country like India would have got no good from railways, but much harm."

RAILWAY POLITICAL ECONOMY.

A Paper read at the Social Science Congress, Manchester, 1879,

LORD REAY IN THE CHAIR,

BY J. L. HADDAN, M. INST. C.E., F.R.G.S.

"The train of wheels within wheels, called Trade, when untrammelled by physical or fiscal friction, constitutes a real perpetual motive machine: upon which high freights and protection act as brakes, and cheap transit and free trade do duty as lubricants.

"Worldly wealth resembles the kaleidoscope, whose elements are primarily meaningless, because inert; but producing with each turn over, a fresh combination."

THE false impression which unfortunately prevails, that the mere construction of stereotyped railways *ad libitum*, indicates progress and prosperity; has led to such a drain upon the floating capital of the country, as to be mainly responsible for the present trade depression: which must continue until the enormous capital sunk during the past decade, in this form of investment, begins to yield a return. (See 'Times' leading article, page 50.)

The average number of years required to make a Stephenson railway pay, corresponds so nearly with the financier's prosperity cycle; as, supported by the following facts, to preclude all doubt that the extended credit system upon which they have of late years been exclusively constructed: produces the recurring spots upon the commercial sun.

Under the system of "guarantees," the financier has used the railway as a stalking horse, to an extent resulting in surfeiting undeveloped countries with luxurious modes of travelling infinitely beyond their means. Even such defaulting States as have practically obtained their railways for nothing; being saddled with a Nemesis in the shape of an eternally high tariff, due to prohibitive working expenses. For a leading authority lays it down that, "If a railway on an important line be constructed on so expensive a plan as to require a high rate of charge to enable it to pay a good dividend; irreparable evil will have been done: and the whole powers of an influential body—influential and powerful, just in proportion to the amount of capital expended—will be brought to bear on that line: not in order to secure cheap transit, but to prevent cheap transit ever being obtained on it."

To Mr. Juland Danvers is mainly due the honour of exposing, by his exquisite Indian railway statistics, the errors of the guarantee system; which has during nearly thirty years been endeavouring to engraft upon Indian soil the English type of means of communi-

cation, which, *prima facie*, is utterly unsuited for a country whose wealth and area are the inverse of each other.

Indian railways started in 1846; but since 1858, they have expended £79,000,000, and have absorbed in unearned guaranteed interest £22,000,000—in other words, a 5 per cent. guarantee not only saddled the future with the interest, but increased the cost price 30 per cent., equal to a direct money subvention or bonus of £4000 per mile. The guaranteed interest and capital expended during India's railway existence has been £166,000,000, upon which only £40,000.000 has been earned. The balance of £120,000,000 has therefore been sunk, *i.e.* withdrawn from that active circulation of capital upon which business, and especially workshop trade (England's *specialité*) depends. Thus, although India has paid the interest regularly; yet for a cycle, England, as far as the immediate present is concerned, is as much poorer by this £120,000,000 as though the investment were Bolivian, Spanish, or Turkish, and the money irretrievably lost. In addition, the total railway capital of the globe is about £3,000,000,000, representing 200,000 miles of railway, of which more than one-third has been invested since the last commercial crisis, none of which latter yet pays a commercial dividend: the non-paying railway capital even in England amounting to £50,000,000.

The railway tariff, both at home and abroad, is of the utmost importance to our manufacturing and agricultural interests; since, firstly, it is the only item in the grand total which constitutes the selling price of our products, which does not vary with the supply and demand: and secondly, in amount it is manyfold in excess of the cost of operatives and labourers' wages, upon the partial reduction of which such unfortunate stress has been laid as to jeopardise our trade *in toto*, by inciting strikes, &c.* While the real offender, the railway tariff, escapes unnoticed; because the man of business in this country has so narrow a view that he never traces his business to its source, but confines himself to the portion in direct contact with his own person.

At Home.—It is now too late to do more than deplore the excessive first cost of our railways; and, therefore, the necessary reduction in inland freights by which England can alone hope to maintain her supremacy, can only be attained by reforms in the system of working; since even after all these years, the profits (which are gradually diminishing) are by no means so satisfactory as to have provided a margin available for reduction.

* The cost of growing American corn is about 8*s.* per quarter; while it is selling in this city at the present moment for 40*s.*: the carriage from London to Manchester alone costing 3*s.* 8*d.*

That the attack should be made in this direction is apparent, when we find that the London and North-Western Railway, with a capital of £90,000,000, only enjoys an annual trade of £10,000,000, a paltry turn over of only a ninth; sufficient evidence in itself of the want of business capacity of the present system of working, and the necessity for its revision; especially when we consider that the working expenses amount to 50 per cent. of the receipts, of which only 10 per cent. represents real value, *i.e.* actual transport cost. A dividend earned under such circumstances must of necessity be onerous in the extreme on the trade furnishing it.

Since, on our railway system, the same rails have to accommodate both goods and possengers, in itself a great mistake and to be avoided in the future (see ¶ 6 page 17); economy absolutely depends upon each receiving most religiously, only its own share of accommodation. Whereas the fact is, that the more than questionably valuable facilities exacted by passengers, who, moreover, do not pay for these privileges; interferes in such a degree with goods traffic, as to force it to run at a like speed—at prohibitive cost—while completely destroying all chance of proper administration in that branch of the service: for while it has been found necessary in the one case to resort to the formidable marshalling, time-tabling, and organisation, with which we are all familiar, and which invariably breaks down under excursion pressure; *goods*, on the other hand, which require it far more, since they can do nothing for themselves and employ ten classes of waggons instead of three, are received any how and at any hour at the concentrated goods depôts; and consequently become inextricably mixed up at the very outset. The result is, that goods are habitually treated to the luxurious elbow room of a Pullman car, and charged accordingly; for consequent upon the feverish haste necessary to prevent a block in the depôts, goods are hurriedly thrown into the first waggon which comes to hand. General sorting is impossible, though partially attempted in France, under the *grande et petite vitesse* system, where eight times the price is charged for quick despatch and no sorting, which is demanded for slow because methodical delivery; although the two classes of goods actually travel in the same train: one enjoying a waggon all to itself, and the other closely packed.

The eight-fold charge (which we habitually use) is made therefore entirely for the margin of space incidental to hurry in the one case; which so greatly outweighs all other considerations of expense, including the sorting and packing into full waggons only attempted abroad with the low tariffed *petite vitesse* goods.

Examples in proof. The Midland, by abolishing the second class, have earned a profit by diminishing the passenger waste-seat margin. On the London and North-Western Railway previous to the quadrupling of the line, the average freight of a 10-ton waggon was not more than one ton, from one year's end to the other, so that the line was not working to more than $\frac{1}{10}$th its real capacity and did not call for the cost of extension; while on the Northern of France, it has been found that not more than 6 per cent. of the waggons are available for active service at any given moment, the remainder doing costly duty as temporary goods sheds, or shut up inextricably in inaccessible corners, &c., playing hide and seek with the merchandise.

This is the cause why railways do not prosper in proportion to the business done; for, when the tonnage passes certain limits, organisation fails; and we find that mediocrity pays better than fame: since many a line with a tithe the business earns even a better dividend. Thus the Metropolitan, an over-crowded line, obtains an increase in receipts of only 2·19 per cent., by an augmentation in tonnage of 13·38 per cent.; while the Caledonian, with only one-sixth the trade total, obtains an increase of 3·61 per cent. in receipts, by an augmentation of tonnage of only 1·18 per cent.: and the Smyrna and Cassaba Railway earns 7 per cent. though running only two *full* trains daily.*

As illustrative of the cost involved in meeting (mostly fallacious) passenger requirements, due to competition, the following will serve. It is erroneously supposed that working through branch trains is a great public convenience; even were it so, it is decidedly the curse of all main lines, every junction being a source of danger and delay, and consequent loss to the main line.

First, as regards the public, it is a mistake, as instanced on the short connecting line between the Chatham and Dover at Wandsworth Road and the South-Western, &c., at Clapham Junction; which is served by a through train once an hour during the week, and by none at all on Sundays: while an engine and carriage oscillating constantly between these two points would put passengers in correspondence with *every* train, on either main line, without any branch organisation whatever. Instance also the Cannon Street branch of the South-Eastern Railway, where, in addition to the delays constantly incurred, every up train crosses the down-line, and *vice versâ*: a far more dangerous system of level crossings than the old road crossings abolished by the Legislature.

Second, as regards the companies, the cost is well illustrated on

* The manager is a Frenchman, M. Redeuil.

the Underground Railway, where four or five companies have each supplied themselves with special complicated rolling stock to perform an amount of traffic which a few extra Metropolitan trains could equally serve, the through trains being at too uncertain intervals to be of any use to the general public, and the luggage difficulty too great to insure their object.

Through branch goods, both Messrs. Oakley and Allport stated before the Lords Committee on Steam Tramways (Session 1878–9), to be not worth while, transhipment being preferable. Break of gauge is not, therefore, of any moment: at any rate on this usually deemed fatal account. Engineers have freely acknowledged that a branch line must be absolutely something different from the parent stem; and traffic managers, for different reasons, hold the same opinion. (Grover.)

Abroad.—The main duty of railways abroad, seeing that they are mostly built with English capital, is to provide us a constant increase of trade area, at any rate commensurate with the marvellous productive powers of our manufacturing centres; due to *their* more judicious employment of steam.

Although ample funds have been provided to engineers for this purpose, they have slain the goose which laid the golden eggs; by stereotyping the English form of railway all over the world, in spite of the fact that in most cases not a tithe of the expense was warranted. Hence, in Australia, where the population is about one person to the square mile, £800 per mile is the average outlay warranted on the trunk lines; £40,000 being the average cost of railways at home. While, in India, the average cost has been £15,000 per mile, instead of at the outside of as many hundreds of pounds.

The fact is, our judgment being biassed by first-class passenger civility, we have been apt to consider the florid mechanical triumphs of the railway as naturally indicating an equally remarkable commercial success; while the late experience of engineers that the Stephenson Railway cannot be reduced either in gauge or first cost, without incurring a certain Nemesis in the shape of increased working expenses; has led the public to believe that it is impossible for railway engineers to cut their clients' coats according to their cloth, and provide ready-money-earning railways capable of procreating themselves regularly, and *ad infinitum*, out of their own earnings; instead of by fits and starts, and invariably with extraneous capital. Had engineers done their duty, and made as much out of steam on the road, as Manchester men have done in the shop; over-production would have been an impossibility, instead of the most incongruous of taunts.

While the telegraph has increased the administrative facilities of trade, we engineers have not kept our inheritance, steam, up to the mark; but have contented ourselves under the financier's ægis, of slothfully trading as Mr. Lowe says, upon the reputation of our fathers. (See page 59.)

We have lately had just a taste in England of the political effect of railway monopolies. In spite of the most carefully devised international customs' treaties, protective duties are either enhanced or nullified by low or high railway rates; and any particular industry may be favoured or dammed by introducing the sliding scale of charges, as exemplified in America; where they carry a quarter of grain 1000 miles for 3*s.*, or about $\frac{1}{6}$th the fair English rate. Moreover, some of the colonies, thanks to the financier, positively borrow our money to do their own commercial dirty work, *i. e.* to construct unremunerate railways with; thereby releasing their own capital (under protective duties) to start competing manufactures. Instead of confining themselves of their own accord to developing their own country, and opening their ports as they would do; if engineers would give them proper export facilities, by condescending to supply them with railways suited to their requirements. Of necessity the profession would have done this ere now, had not loan-mongers' money been hitherto so readily forthcoming for stereotyping the railway proper; as to conceal that publicly recognised necessity which nowadays can alone afford to invention—both the necessary incentive and its subsequent development. The first principles of colonisation are outraged by the ordinary railway. which concentrates instead of disseminating the resources of the country. Nor will either they or ourselves get into our respective grooves, until English investors learn that guaranteed interest cannot really prove remunerative, unless the object does not require long credit for its development. The Governor-General of Canada has just opened the *Credit* Valley Railway. It doubtless merits its name, since it must lead to the same goal as Canadian railways in general.

To render international trade-statistics of any value, money should be included in our articles of export.

I am prepared to show on a more fitting occasion, how full waggons can always be assured in conjunction with rapid delivery, and, consequently, a general reduction—say, of 75 per cent.—in the transit rates obtained, with the most signal results upon our trade.*

* A full description of the method proposed will be found in a paper entitled "Military Railways," read at the United Service Institution, on the 20th May, 1878: and a brief summary at ¶ 6A, page 18 of this volume.

We could then safely leave the operatives a little cream on their milk; and, perhaps, sugar with their porridge: without upsetting the overstrained labour market.

Although many of the grave errors incidental to making and working English railways—of which the above are but a few specimens—cannot be remedied; they should be frankly acknowledged, if only to prevent our colonies from falling into like errors; consequent upon their stereotyping the Stephenson railway, in blind confidence as to its general efficiency even under totally different conditions, to which, however, other engineers have misapplied the great inventor's rules.* It would be out of place here, however, to show how, with the gigantic strides mechanical productions have made since Stephenson's time; it is quite possible to make a different type of railway, in which earthwork and masonry being abolished, and metal exclusively employed: the whole capital could be made use of at home in producing export railways cut and dried ready for use, at a cost not exceeding £1000 per mile, and therefore capable of earning their own living from the outset, and rapidly procreating themselves out of their earnings—under even the most unpromising conditions—instead as of, in India, after an expenditure of £114,000,000, being still unable either to start or run alone. Its punctuality in paying guarantees not proving itself in this case the soul of business our proverbs state this virtue in general to be.

I would in conclusion, draw public attention to one of the main causes why railways, in conjunction with so many other overgrown enterprises, are so wastefully managed. The financier's recommendation to investors, not to risk all their eggs in one basket, has so split up the capital, as to make it worth no one's while to look after the administration—save the mark!

* Russian Railways.—Not only were the necessary ideas, but the necessary money, says the 'Molva,' borrowed from other countries in Europe for the construction of Russian railroads; and what, it asks, are the results? On an average, the gross receipts from the 20,000 versts (15,000 miles) of all Russian lines amount to about 10,700 roubles (£1500) a year; while in Western Europe the net revenue of such an enormous network of railroads would not be less than 50,000,000 roubles (£7,000,000), after paying the necessary interest and for the regular amortization of bonds. "Our *sagacious* engineers and railway administrators, however," concludes the 'Molva,' "have so succeeded in working the lines under their charge that, the Treasury, on the credit of which all the railways were built, has a yearly deficit in this respect alone of from 35 to 40 millions (£5,000,000). Such is the result of the knowledge and experience of our skilled railroad builders, who, after all, have become very rich men." That such persons, evidently thinks the 'Molva,' from the whole tone of its article, should assemble and toast the memory of George Stephenson is as easy of explanation as that grateful devotees should kiss the relics of their patron saint.—'*Times*,' October 13, 1879.

OPINIONS OF THE PRESS.

ASIA MINOR AND THE EUPHRATES VALLEY.

(*From the* 'LEVANT HERALD,' *Nov.* 12*th*, 1874.)

On Wednesday last, Mr. Brassey, M.P., Mr. Foster, C.B., director-general of the Imperial Ottoman Bank, and a number of other gentlemen; were invited to examine a working model of the "Pioneer" Railway, by Mr. John L. Haddan. After explaining the mechanism of this economical mode of transport, the inventor read the following short paper, pointing out the peculiar merits possessed by this system as *an auxiliary*, both in the construction and in the nourishment of the contemplated Asia Minor railways:—

Turkey being eminently an agricultural empire, but sparsely populated, and whose revenue is mainly derivable from the soil; it becomes a necessity of primary importance in the construction of the public works of the empire, if *of any extent*, to arrange so as to interfere as little as possible with the labour market.

At first sight, it seems that the means of avoiding this serious and costly evil, is only to undertake works of small amount and to extend these operations very gradually; but, taking into consideration the vast extent of the empire, as also the fact that its existing means of communication are quite inadequate even (as at Angora) for local purposes.* it is only too evident that far too much *time* would be required for commercially opening up the country in such a dilatory fashion. Yet, as labour in any large quantity, even at high prices, is not procurable; we must perforce seek some other means of energetically extending the railway system, so as to meet the well-known wishes of H.I.M. the Sultan and the Grand Vizier in this respect. This duty the "Pioneer" performs, without undue interference with the agricultural pursuits of the population.

In addition to the quite exceptional roughness of the country, which forms another retarding element; we have other difficulties to surmount, and which the "Pioneer" either remedies or palliates. As, for instance, owing to the non-existence of means of communication, the commencement of operations at numerous points is impossible; also, consequent on the high rate of interest prevalent in the empire, *local* shareholders cannot be obtained for any public works requiring long periods for their construction. Moreover, the Government guarantee, granted also during construction, falls heavily on the State, yet as European capitalists exact this guarantee it must be accorded; still, it may manifestly be diminished with advantage by the employment of all legitimate means of increasing the extinction of the guarantee by feeding the main arteries so that they shall pay. These means the "Pioneer" affords; during construction it lends valuable aid as a labour economiser, and subsequently, when converted into branches, as a feeder.

In a country where no cross roads exist, and where the supply of animal transport is naturally limited, branch lines become a strict necessity; for on main lines of great length, it is now universally acknowledged "through" goods traffic does not pay, so that the only source of nourishment available is then local.

To summarise:—We require for the economical yet rapid construction of railways in Turkey:—

1. A mechanical means of economising manual and animal labour.
2. Great rapidity of construction, so as to reduce the interest on capital during construction.
3. The construction of branch lines simultaneously with their main arteries.
4. *Through* communication, though of small capacity, in preference to fragments of line on a large scale.

* The freights on grain from Angora to the coast cost 5 piastres per oke, the value of the grain being 1¼ piastres per oke. There is not a single cart road in the whole province.

The "Pioneer" fulfils all these conditions, and that in the following way :—

As an *avant-coureur* of a great enterprise, the "Pioneer" would be constructed entirely of iron. The fixing thereof requires but eight simple operations per 24 feet, viz., driving two short piles into the ground, and fixing six bolts; so that with only a hundred "trained men" (soldiers would do), a daily advance from each *point de départ* of two or even three miles could be constantly maintained. Its own materials are carried forward step by step by the line itself, the road being laid ready for use at one operation. The "Pioneer" would be pushed forward to the terminus as rapidly as possible, following at a guess, but not to the letter, the future *trace*, purposely however deviating where required to open up forests for sleepers, coal-mines for fuel, quarries for stone, gravel-pits for ballast, &c., &c., acting, so to speak, as contractors' plant, and, when established, permitting the future works to be carried on at an infinity of points, yet under perfect surveillance and control, without the use of an inordinate staff of employés. While, however, performing contractors' duty, the "Pioneer" would likewise be used for the transport of passengers, mails, and goods, for which its scale would be amply sufficient for the time being; producing a profit probably sufficient to pay the Government guarantee during the construction of the trunk Railway; affording, moreover, reliable statistics for the enterprise proper; and lastly, but not leastly, so assisting its successor as to reduce the cost of the main line perhaps as much as 30 per cent. In proportion as the main line overtakes the "Pioneer," the latter is at once broken up into branches to feed the former, and render it profitable at the earliest possible moment.

Taking the Euphrates Valley Railway as an example, the "Pioneer" could be so rapidly constructed that the mail route to India might be established in about a year, and thus immediately earn the proposed mail subvention of £300,000 annually, which pending the completion of the main line (say seven years), would be more than sufficient to repay the outlay required of £1,000,000, plus the 12 per cent. interest for the use of the capital, to say nothing of its future value in branches.

The tariff chargeable would be a mean between the present telegraph and postal rates, established on the basis of the saving of time in the transmission of news.

An enterprise of this nature may be rather likened to a military expedition than a railway one, the "Pioneer" forming the base from which the men and materials employed would be supplied.

A favourable impression was created by the inspection, and the conviction was expressed that the "Pioneer," if it prove mechanically a success, is adapted in all other respects to the wants of Turkey.

Mr. Haddan also mentioned incidentally that the introduction of agricultural machinery would necessarily follow the opening up of the country by the "Pioneer;" the use of such labour-saving implements affording the only means by which the limited population of the empire can possibly extend its operations. At *present* the introduction of such machinery is impossible, owing to the non-existence of repairing shops. This want, however, the "Pioneer" would likewise supply.

RAILWAY ECONOMICS.

From the 'TIMES,' *January* 6, 1875.

THE "PIONEER" RAILWAY.—The doctrine that the only way to develope the resources of a country is to build railways cannot be said to have died out yet, but it is scarcely so rampant now as it was a few years ago. Except for the support of the Government, even a richly-productive, thickly-peopled country like India would have got no good from railways, but much harm. The conditions which go towards causing railways to pay are difficult to indicate, but it is at any rate clear that much more is wanted than richness of soil or of minerals, or even density of population. Unless between towns, which are centres of trade, railways to do any good must be supplemented by good roads, and those do not exist as a rule either in new countries or among populations in decay, or where the centres

of industry are far scattered. To the mass of the rural population in any country where civilisation is either dying or has hardly come into being, a railway means a costly mode of drawing the people away from their valleys, of denuding one part of the land that the other may be thickly peopled; it is a burden grievous to be borne, laid upon a population too poor to pay remunerative charges, too far scattered to become great travellers.

In no country has this description of the outcome of railway building a truer application than in Turkey. From beginning to end the story of railway enterprise there has been one of disaster. To no small extent this is due to the incompetence of the Government, but far more largely it lies in the nature of things. Turkey has vast natural resources, no doubt, but they are utterly wasted; there is no internal order, no effort at production such as characterises a civilised or progressive community; there are no roads which can act as feeders, or but very few, so that a railway when made only ties city to city, or taps a thin line of territory on each side of its route. So Turkish railways do not pay, and have only helped to pile the load upon the back of the poor misgoverned country, till it is all but broken.

Yet, in a very different sense, means of intercourse between district and district, province and province, city and city, is beyond measure essential to Turkey if the country is to be saved from sudden collapse. If one could keep the tax-farmer away or in check, the people would be stimulated to expend energy in raising surplus crops of wheat, in reviving manufactures (now dying out, if not already dead), could they only get rid of their works or their produce at a fair profit. That is not possible while bridle-paths form the sole arteries along which what life and movement is in the country painfully flows. Turkey wants roads, therefore; but at the same time, railways as now made are too costly for so poor a country, and would remain so, it is to be feared, after the development of many years. They ought to *follow* the growth of the country in several ways instead of *preceding* it by so long, and are too rigid a means of intercommunication in a half-peopled agricultural territory, where the centre of business at one time may not be the centre when new outgrowths of cultivation or new settlements of the people have been created. A railway laid down in a country like Turkey, in the mode we are accustomed to lay railways down in England, is a deed done in a measure for ever, but the actual condition of the population which determines the route now, may by no means be those that will be in existence a quarter of a century hence. For poor countries to benefit by such a great help to intercommunication, lighter, cheaper, more movable forms of railways should be made. There has been a stereotyped idea regarding railways, which has led to the reproduction of the same thing all the world over—in Japan as in England, in Egypt as in America—without much regard to surrounding conditions. This has helped not a little to make the result so often disaster, instead of progress.

It appears to have been from a perception of such truths as these that a well-known English engineer in Constantinople has occupied himself in designing a new form of railway, which will be of this lighter kind. He calls his invention the "Pioneer," and means it to *precede* rather than to *supersede* other railroads; to be, at all events, the first form of railway which poor, agricultural, and thinly-peopled countries should possess, so securing to them all they need in the way of cheap and rapid carrying power, without burdening them with either the original cost or the permanent outlay involved in making ordinary railways and keeping them efficient. The construction of this "Pioneer" railway is simple and ingenious. Instead of requiring the ground to be elaborately prepared for the rails, and gradients carefully adjusted, it may be made almost anywhere, and involves little outlay. The carriages and engine are in shape much like a couple of panniers, and the railway on which they run answers to the donkey's back, it being a single central rail laid along an elevated narrow platform, which may be supported on tressels or merely on posts sunk well in the ground, as desired. In addition to this centre rail, on which the carriages are hung and where the friction of the running wheels is, there are two side rails which jut out on cross bars so as to catch a wheel running on each side of the carriages below. These latter rails answering to the sides of the donkey or pack-horse, serve to steady the train, and also supply a means of applying the tractive gripping power whereby the train can be pulled up very steep inclines. The mode of construction necessarily causes

all the carriages and the engine to be divided into two equal halves, and thus cuts down the stowage room, but enough seems to be left to afford ample accommodation for passengers where they are not likely to be numerous, and to afford room for a great deal of comparatively heavy traffic. When erected, this railway presents at a distance the appearance of a strong fence, it being so far above the ground, and this form of construction makes it an easy matter to get over difficulties in the configuration of the country. Where advisable, the top rail is laid on posts stuck in the ground, and should these not be procurable, or should the soil present obstacles to their being securely rooted, then tressels may be used, or a dwarf wall 2′ 6″ high may be built of masonry or concrete. For crossing streams the expedients are essentially the same, only the posts are longer. The sides of a mountain may be climbed by this railway with ease, and its inventor, Mr. Haddan, claims for it these various advantages in other respects:—Rapidity and low cost of construction. Employment of marketable materials only, earthworks being entirely dispensed with; capacity, therefore, of constructing a railway at a fixed factory, and of making it instantly transport itself. Low working expenses. Portability, it being easy to remove the whole apparatus from one locality to another: hence, also its value in aiding the construction of a solid railway of the ordinary kind, and its subsequent transfer into branches for feeding the same.

Whether this railway has been practically tried or not we cannot say, but there is a good deal about the aims and conceptions of its inventor with which we must sympathise. It would be a great help to Turkey and to many a country besides, if a means of transport such as this affords could be readily organised, for these would then have a help to the development of trade and agriculture, and, consequently, of population, which costly railways and their attendant loans and heavy taxes can never supply. Mr. Haddan is sanguine enough to hope that the speedy adoption of his system would do much to regenerate Turkey even yet. There certainly can be no reason why his railway should not be tried where it may be likely to do good in that or any other country, for if at all as practicable as the models of it look, it should prove useful in many ways and places where it would be vain to hope for an ordinary railway this many a day.

MILITARY RAILWAYS.

From the 'TIMES,' *June 15th*, 1878.

TO THE EDITOR OF THE 'TIMES.'

SIR,—However abhorrent war may be to our feelings of humanity in general, and however much we may deprecate it in the interests of our own country in particular, I think no one will refuse assent to the proposition that if we are obliged, now or hereafter, to put an army in the field, it should be furnished with every requisite for success that the advance of science places at our disposal. I understand that in the prospect—happily now less imminent—of an expeditionary force being despatched from these shores, some miles of field railway have been prepared at Woolwich, with a locomotive of novel pattern which has been judged likely to render more useful service, under the probable requirements of a campaign, than one of the ordinary description. I need hardly remind you that ever since the Crimean war a campaign has never been undertaken by this, or, perhaps, by any other European country, without the attempt being made to facilitate operations by the aid of the railway. In no one instance, however, that I can recall has the attempt been a striking success. The Balaclava railway was notoriously unsatisfactory; that constructed for the Abyssinian campaign was scarcely less disappointing. The field railway undertaken by the Germans in 1870 to preserve the continuity of their railway communication while Metz was still unreduced, is now known to have been of little practical use, owing chiefly to the sinking of the earthworks. In the Ashantee war, though some miles of railway accompanied Sir Garnet Wolseley's force, it was never, I believe, even disembarked. Will the railway to which I have referred as being now in readiness at Woolwich prove more useful than those which have preceded it, should it be put to the practical test?

This question of field railways formed the subject of a paper which was read last month at the Royal United Service Institution by Mr. J. L. Haddan, an eminent railway engineer, upon which you published some favourable comments at the time. Mr. Haddan contended that we have proceeded hitherto upon a totally wrong system in assimilating the construction of field railways to that of ordinary railways, and proposed in substitution a one-rail surface railway supported upon dwarf trestles or posts, and entirely independent of earthworks, either banks or cuttings. The locomotive proposed for such a railway is of peculiar and very light construction, deriving its tractive power, not from the combination of steam-power and gravity, like an ordinary locomotive; but from steam-power, and the "grip" it is made to give upon the rail. The reduction in the weight of the locomotive, and the corresponding reduction in the size and weight of the carriages, lighten also the necessary weight and strength of the road, without, however, diminishing the carrying powers of the latter; the freight, by Mr. Haddan's invention, being merely lengthened out and made to travel in Indian file, so to say, instead of in "sections."

Mr. Haddan claimed for his field railway the following advantages, among others, which, if they can be substantiated, it is impossible to overrate:—That it is more simple, more quickly and easily constructed, than any existing type of railway; that it is practically almost independent of gradient and other local considerations, the locomotive employed being able to take a train weighing 100 tons up a gradient of one in ten; that it requires neither embankments nor cuttings; that it may be made beforehand to an unlimited extent in our national workshops, either of wood or iron, at a very moderate cost per mile, and conveyed, ready for use, and only requiring to be put together by the troops, to the place where it is intended to be laid down; and lastly, that it can be laid down at the rate of one mile per diem for each 100 men employed. I can well imagine that Mr. Haddan's views will not find favour at the hands of rival inventors, and that professional jealousy will be roused at proposals which cast a doubt upon the inventive resources of those who have preceded him in the same field. But what have the Government or the public to do with that? If Mr. Haddan's theories can be shown to be sound, and susceptible of ready conversion into practice, by all means let him have the credit he deserves, and let the country, in its next war, benefit by the adoption of them. Sir Garnet Wolseley, who presided when Mr. Haddan's paper was discussed, and than whom there can be no higher non-technical authority, expressed himself very favourably in regard to it, and such I feel sure will be the feeling of all military men who heard or may read it. Your own comments also in the 'Times' of the 30th of May adopt Mr. Haddan's tenets;—

"But, alas! those heavy waggons, long pontoon-boats, telegraph waggons, and photographic carts all mean roads; no provision seems to be made for transport over uncivilised countries such as we now wage war in. It is much to be feared that the present system, advanced as it is compared with the old, which left everything to be arranged after the outbreak of war, is scarcely adapted for the Bulgarian or Armenian roads, admirable though they are on our macadamised highways in Great Britain."

Surely the Secretary of State for War could not do wrong to obtain the opinions of Colonel Yolland and his colleagues as to the technical merits of Mr. Haddan's field railway, and so clear the way for its early adoption as the field railway of the British service, if it is shown on competent authority to deserve that distinction?

Your obedient Servant,

J. L. VAUGHAN, Lieutenant-General.

Junior United Service Club, June 12.

MILITARY RAILWAYS.

From the TIMES,' *June 17th*, 1878.

TO THE EDITOR OF THE 'TIMES.'

SIR,—To General Vaughan's comprehensive letter which appears in the '*Times*' of the 15th inst., there is but one single word therein to which I can take exception, and that is to the term "inventor" which he applies to me. My "Pioneer" railway, so often noticed in your columns, comprises no startling novelties; it is merely a combination of various thoroughly proven and accepted mechanical and natural laws. Inventions, properly so called, must be left to philosophers; but, although it is now the fashion in our profession to stereotype, a small minority will always maintain that it is the civil engineer's proper and only province to ring all the changes of natural combinations, which are quite as numerous and infallible as chemical ones, in applying his art to meet all possible requirements, especially so varying as those of transport. Mechanics of late years turn out such marvellous giants, great in body, but, like ironclads, very weak in the ribs, that they have insensibly smothered their professional civil brethren, and the stereotyping of railways all over the world, which has led to such disastrous commercial results, is mainly due to their unbending mechanical pride, which will not stoop to meet any other requirements but those of their own shops or prejudices. The same incubus has hitherto borne fatally upon military railways. All the pomp and circumstance of 60-ton locomotives, Pullman cars, 80-lb. rails, gigantic earthworks, and colossal masonry, matters of pride and congratulation in the civil engineering world (?), must perforce be carefully eschewed in designing a military field railway, and may, with advantage, be pursued *ad absurdum* in those countries where travelling at present is a necessary evil and by no means a luxury.

To the English Army, where men are inordinately valuable as their numbers are few, and for agricultural empires where every man's labour is in a short season productive many hundredfold, and where the State revenue is dependent on his labour, there can be no greater mistake in political economy than to employ animal labour in making earthworks, the most unproductive of investments, even when converted into a railway. After a war or famine this argument has still greater force. Far better, therefore, than inventing steam sappers to make earthworks, and so adding another complication to military duties, the "Pioneer" glories in abolishing earthworks altogether; and, moreover, supplies another article of export to our home list, since it can be manufactured complete in working order in the workshops of Great Britain, and sent out in any quantity to its destination. Turkey, so incapable of helping herself, may be thus developed with English iron, a far safer investment than English gold; and India, a prey to famines and unequal exchanges, may benefit in like manner by the use of a means of communication especially designed to meet her wants.

J. L. HADDAN.

25, *Great George Street, W.*, June 15.

PIONEER AND MILITARY RAILWAYS.—A section of a novel military or pioneer railway was built on Monday, on the ground lying waste at the rear of Whitehall-place, in four hours; and to show the simplicity of the work, its constructors were ten soldiers, sent as a fatigue party from the Grenadier Guards, and one or two ordinary unskilled labourers. This railway is the invention of Mr. J. L. Haddan, ex-engineer in chief of the Ottoman Government; and the railway was primarily designed to meet the need in the East of having a speedily-constructed, cheap, and effective means of transport for men and stores over a wild country without the necessity of surveying, levelling, and passing through the preliminary stages of ordinary railway making. The new railway built on Monday in the grounds of Whitehall is a "one-rail" structure, and the line it represented requires neither sleepers nor foundations, the line running upon dwarf posts, 440 to a mile, the rolling-stock upon it being shaped like an inverted V, designed upon the

"camel-saddle" principle. The carriages and engines fall on each side like panniers on an animal's back, the safety wheels of the engines, trucks, and carriages being horizontal. The material of the new railway is wholly of timbers, which were brought on the ground ready cut for use, and the plans having been explained to the sergeant of the fatigue party, the piles were sunk in the ground, the cross timbers were readily fixed and bolted, and by a series of ingeniously designed wedges an 80-feet or 100-feet section of the line, running over very uneven ground, was made secure and apparently quite solid. In the evening the inventor read a paper on the subject at the Royal United Service Institution, GENERAL SIR GARNET WOLSELEY, K.C.B., presiding.

During the discussion which followed the reading of the paper, Sir Garnet Wolseley, speaking of the railway in the Crimea, said "that, though that was not a great success, it was very useful, and by making it the English nation was the first to use railways in war. The great thing in regard to railways used in war was that they should be quickly made and worked, for time was everything. If we had to go to war and to operate inland in a country where there were no roads, it would be of the greatest importance to have a line from the base to the scene of operation, and Mr. Haddan's proposals gave a system which would meet the requirements of an army in that position. As to particular railways which had been proposed for army transports, in these days of short and sharp campaigns earthworks were out of the question, for now armies did not sit down to long campaigns like the sieges of Troy and Sebastopol. Other systems required good roads, but for a country without the roads, and in rapidity and simplicity of construction, Mr. Haddan's railway would meet an army's wants." The proceedings lasted until 11 o'clock at night, and the company then went to view the section in the grounds at Whitehall, lighted by port fires.—*The 'Times,' May 22nd*, 1878.

* * * * * * But, alas! those heavy waggons, long pontoon-boats, telegraph waggons, and photographic carts, all mean *roads;* no provision seems to be made for transport over uncivilised countries such as we now wage war in. It is much to be feared that the present system, advanced as it is compared with the old, which left everything to be arranged after the outbreak of war, is scarcely adapted for the Bulgarian or Armenian roads, admirable though they are on our macadamised highways in Great Britain.—*The 'Times,' May 30th*, 1878.

INDIAN RAILWAYS.

From the 'TIMES,' *June 17th*, 1878.

The conclusion Mr. Haddan arrives at is nevertheless worth attending to. Where a regularly constructed railroad is, for any reason, too costly a thing to yield a profit, there may be room for a lighter line—a Pioneer railway, as Mr. Haddan terms it—to be sent out ready made from this country and fit for use as soon as it can be laid down. We can hardly doubt that some such simple affair as this might very advantageously have taken the place of some, at least, of our Indian lines. Still more useful would it be for extensions into less favourable regions. When the start had been given in this way, there would be room afterwards for the more elaborate and more costly railway proper, with all its pomp and circumstance, its sixty-ton locomotives, its eighty-pound rails, its gigantic earthworks and colossal masonry, and all the rest of which our correspondent speaks with a disfavour not common in his profession. There is plenty of space still to be found for the experiment both in India itself and in the countries bordering on India. The want of feeder lines is much felt by almost every one of the great Indian railways. It is kind of Mr. Haddan to suggest that we should supply Turkey with lines of the sort he favours. There is no reason why we should not do so, if we can induce Turkey to purchase them from us.

But the need of them for India is equally obvious, and we might hope for something better from them, at all events, than the poor return of "less than 1 per cent."

AFRICA OUR SECOND INDIA.

TO THE EDITOR OF THE 'MANCHESTER COURIER.'

SIR,—Your townsmen should be the first to scotch the following Indian and colonial worm in the bud of free-trade; and, moreover, see they do not fall into like error while supporting Mr. Bradshaw's excellent project for developing Central Africa.

This parasite, which is attracting so much attention in Manchester at the present moment, is English born and bred; and its remedy is also in our own hands.

Its origin is really due to the hitherto deemed necessary evil of railways in general being as a matter of course unremunerative for a season. Hence in India, the colonies, and many of the minor foreign States; railways are undertaken with, to them, foreign money: not so much because they have not the requisite funds themselves, but because the guarantee or profit is not good enough to attract their local capitalists.

The local investor is, therefore, forced to seek by protective duties to form an artificial field in which to utilise his capital, although he has to do it of course at the expense of his countrymen.

Every means of increasing exports, of which railways with low fares is the essence, should form a local investment. That this order of things is reversed, is the reason why the colonies cannot accept free-trade; and why without, however, the same excuse, they behave more or less like the Indian ryot of the interior, who, cut off from freedom of trade by his isolated condition, is forced to be conservative and cultivate for himself a patchwork holding, producing every personal want, from cotton to tobacco.

The remedy rests in the hands of our mechanical engineers, who, having slain the goose which laid the golden eggs, must now produce remunerative or ready-money railways, on a scale and extent suitable to the colonial requirements, viz.; of small purse and huge acreage.

The remedy in India, or where many railways already exist; is for the Government to accept the fact that a railway dividend obtained by high fares is merely a sign of individual prosperity, gained at the expense of the imports and exports of the country. The guarantee system is rotten, and the Government refuse to extend the system; it is not sufficient in amount to attract local shareholders, nor does it induce economical administration.

The main lines should all be State railways, on which the earning of a dividend should be the *last* consideration. But if private local capitalists are desirous of making branch railways, the Government should fix their tariffs unremuneratively low, and make up the difference in the shape of a subvention per ton and per passenger, in lieu of per mile. This would so encourage exports that the local capitalist would leave cotton-spinning and such like home work to those who can do it so much better and cheaper. I may mention that for the last ten years I have been elaborating a steam caravan or Pioneer railway, the cost of which, of a carrying capacity equal to the narrow gauge, does not exceed 1000*l.* per mile in running order. The whole is in iron, erected by the mile or so daily, and is, in fact, a continuous low fence or bridge; there are no earthworks, and local labour is not wanted; its route is "as the crow flies." English hands, shops, and capital, supply the whole in the shape of one of our staples—iron—instead of sending the gold to foreign countries to perform what may be called their commercial dirty work, leaving them free to invest every penny of their own in starting local rival factories to our home manufactures. Export manufactured iron, not gold, is my panacea!

Yours, &c.,

J. L. HADDAN, M. INST. C.E., F.R.G.S., &c.

March 3, 1879.

INDIAN BREAK OF GAUGE.

TO THE EDITOR OF THE 'TIMES.'

SIR,—"Australia has five different breaks of gauge already," and already finds their rectification beyond her resources. "Could we only begin again," formed the sorrowful key-note of a paper read a few weeks back on Colonial Railways at our Institution, under the able presidency of Mr. P. Barlow.

It was almost the universal opinion, founded upon facts, that the question was decided in favour of the broad gauge; "since, so long as concentrated weight constitutes, as it does, our locomotive tractive power, the broad gauge must from the very outset be the cheapest to work; that the apparent saving in first cost offered by the narrow gauge was delusive, since the balance was more than covered in the early future by the saving in working." In fact that on existing principles, a cheap light railway is an impossibility, and a delusion and a snare to those who so falsely think the first cost per mile a criterion of value, either present or future; first, as regards the present, because lines may be lengthened to the most extravagant extent, as so ably practised by Baron Hirsch in Roumelia; and secondly, as regards the future, the banks and cuttings *so* necessary for securing easily workable grades; may be, and are, cut down to such an extent, as to reduce the effective train load to *nil*.

Hence the Government did quite right to refuse to construct a *surface* line to the Bolan Pass—first, because Sir Henry Green says the winter rains would wash any closed structure away; and secondly, because Crimean * experience showed that on a *surface* line the grades were necessarily so steep, that horses, stationary engines, and locomotives, combined with a staff of 1000 men, failed to carry a paying load over less than a dozen miles of line.

Yours, &c.,

J. L. HADDAN.

25, *Great George Street*, March 3, 1879.

THE KING OF THE BELGIANS AND THE PIONEER RAILWAY.

His Majesty the King of the Belgians, attended by Major-General Gardiner, visited the theatre of the Royal United Service Institution yesterday, to inspect the Pioneer railway, invented by Mr. J. L. Haddan, M.I.C.E. There were also present Admiral Selwyn, Mr. Berry (Prime Minister of Victoria), Capt. Burton (the African explorer), Mr. Grover, M.I.C.E., the Consulting Engineer, Mr. John Kendall, Capt. Haddan, Capt. Burgess (the Secretary of the Institution), and other gentlemen. It was explained to the King (who is the President of an African Exploration Expedition) that the railway was intended to apply to countries like Africa, Cyprus, and the Northern Provinces of India, which could not afford the construction of a first-class railway, owing to the paucity of the traffic. The principle was that of a single rail, the centre of gravity being kept very low so as to prevent oscillation. The system of driving was applied to all the wheels of the train in a manner analogous to the continuous brake reversed. Thus the whole weight of the train was available for adhesion, and grades of 1 in 7—or a crow's-flight route—gave the system a direct right of way even in mountainous countries. The cost of the erection of such a railway in timber would be about £700 a mile, and entirely of iron about £1500 a mile in running order complete; but in contradistinction to roads and earthwork railways, where the cost of maintenance against the weather alone was at least equal to £1000 per mile capitalised: the Pioneer, by abolishing earthworks, started with a negative subsidy of £1000 per mile. It

* At Metz, under more favourable conditions, since the works were in connection with existing railways, the result was equally disappointing.

was eminently suitable for military purposes, so that troops might erect the railway as they went on, and carry their stores with them—really hold the ground they occupied. After the principle of the construction had been fully explained, his Majesty went into the grounds at the rear of the Institution, and saw a full-size section in timber erected by a party of soldiers. It was also stated that the system was now past the stage of theory, as an eminent engineering firm had guaranteed the construction of the engine as designed by Mr. Haddan, and another firm had guaranteed the stability of the road to which the system should be applied. An offer had also been made to the Indian Government to supply such a road for the service of the troops in Afghanistan, and it was stated that the offer had been strongly supported by the recommendation of the Home Government. His Majesty expressed his thanks for the lucid explanations afforded by Mr. Haddan.—*The 'Globe.'*

ELEPHANTS FOR AFRICA.

TO THE EDITOR OF THE 'DAILY TELEGRAPH.'

SIR,—His Majesty the King of the Belgians certainly deserves well of civilisation in that he will not leave a stone unturned in his search to open up the Dark Continent. Some one has suggested elephants to him, and he goes into the question with his accustomed energy. That carriage must be found is clear, for Mr. Bradshaw shows most conclusively that all the African ports are already flooded with Manchester goods, and relief can only be attained by extensions inland.

That famous "white elephant" the English railway, is out of the question; since, let alone its first cost and its inability to run alone for years; the insurance against the effect of tropical rains upon their earthworks will alone amount to £1000 a mile, if capitalised—an objection equally applicable to roads. The natural animal so far resembles its prototype that it deludes the public by offering a brilliant mechanical success contemporaneous with commercial failure. An elephant weighs 60 cwt. and can carry only 15 cwt. Unless the road is good he suffers from sore feet. He requires in hot weather a bath twice daily. He is equally with other cattle affected by climate. His daily rations are costly and epicurean, viz. 25 lb. of chupatties or cooked flour cakes, and about 175 lb. of hay. His maintenance costs about £150 per annum, and calculating from Sir Garnet Wolseley's admirable data, the cost of elephant transport, even when organised, will not be less than 2*s.* per ton per mile.

Mr. Juland Danvers' Indian railway returns show that even at a cost for transport of only 0·35*d.* per ton per mile, many bulky substances cannot be exported; it is evident therefore that with a tariff of 2*s.* per ton per mile the elephant transport would be restricted for general purposes to but a few miles inland? so *cui bono?*

If ever there was a country where common sense suggests the conversion of her forests into transport power it is Africa, where animal-carrying force is at such a discount as to have suggested relief in enslaving men for the purpose. When inspecting my Pioneer or African steam caravan, his Majesty only expressed a fear that capitalists would require some form of guarantee, before investing even so limited a capital as was required for its installation—viz., £1000 per mile. I had the honour of pointing out to his Majesty that the days of so-called guarantees were fortunately over, and that our profession was at last alive to the disgrace of having slain the goose which laid the golden eggs, by sinking millions in unremunerative railways, instead of making them on a scale capable of extending themselves *ad infinitum* out of their own earnings.

While unlimited capital has been freely given us, we have, by squandering the means afforded, most signally failed in the imperative duty of keeping pace with the productive power of England by supplying it with fresh markets. We engineers are responsible for the trade depression, and no one else; for it will take ten years at least before the railway capital already sunk will earn enough to extend itself. While steamers daily work more economically; railways, under financial treatment, daily become more unsatisfactory.

J. L. HADDAN.

Extract 'SOCIETY OF ARTS JOURNAL,' *May 2nd.*

Sir Henry Tyler, than whom no one possesses greater knowledge of English railways, dubbed Bosnia an impracticable country, and very justly so, as regards the ordinary railway; but are such countries going to accept isolation from civilisation because our motto is "*Aut Cæsar aut nullus*"—the English railway or nothing? There are whole continents in a similar position; and our profession will, let us hope, mark the pertinent remarks offered by Colonel Stanley, Mr. Lowe, and Sir Michael Hicks Beach, at the annual dinner of the Institute of Civil Engineers, for they all three inculcated the same lesson. Colonel Stanley (no doubt fresh from the perusal of returns of the irremediable loss of animal power lately experienced in the Zulu and Afghan campaigns), reminds the profession that although the condition of a great portion of our vast empire brought us face to face with primeval times as regards transport, we had nothing suitable to offer. Mr. Lowe followed suit, and blamed us for so abjectly treading in the footsteps of our fathers, whose rapid success had intoxicated the universe, whose varied demands, however, we had not met, except by a stereotyped system. Sir Michael Hicks Beach, referring to the commercial failure of colonial railways, gave the *coup de grâce*;* when he reminded us that the vast area of the colonies, and their inversely small means, called for anything but the grandiose treatment of our mammoth English lines, the charges to support the mechanical luxury of which, it cannot be denied, are fast destroying our export trade. Wages are reduced, hours are lessened, but railway tariffs (as much an export tax as if levied by the Customs), still maintain a price which might be reduced more than one-half if economical principles were employed. The existing wasteful railway is guilty of the present depression of trade. The vast sums confided to our possession for making railways to extend our markets have been sunk in unprofitable railways, and not invested in procreative means of communication, the immediate profits of which would have pushed railways on at a pace commensurate with our industrial production, and not have come suddenly to a full stop, leaving all the markets of the world glutted, and no outlet possible. Railway construction, to be economical, must be designed quite as much to meet the actuary's requirements as purely technical ones. Hence, to obtain a fair comparison between any two or more systems, the durability of the materials are a most essential feature; and therefore in submitting an estimate the costs of repairs and working expenses should be capitalised: for the cost per mile is utterly unreliable, as it neither illustrates the length, quantity, or quality, nor the durability either. One example: the abolition of earthworks means, in the case of an ordinary road or railway, a saving of annual maintenance equal to a minimum of £1000 per mile capitalised, and to a maximum of over £5000 in tropical countries, where the yearly rainfall falls in a few days or hours. The prize, therefore, offered to an elevated railway is a great one, but it cannot be even mechanically obtained on the gravity system, except at a fatal sacrifice of efficiency. It is not surprising that in the face of recent railway investment failures, the general public should cry down railways and put their trust in animals, which are quite as unreliable, however, as the proverbial princes we are warned against. The bare idea is retrograde, for steam properly applied can beat animals hollow.† African climate is against their use, and their concomitants, roads, which never can pay commercially, because the wear and tear on them, as upon a tramway, is mostly due to extraneous causes.

J. L. HADDAN.

* Lord Salisbury in his recent evidence on the East India Bill has added another claim to the gratitude we owe the present government for exposing the errors of the Railway system.

† Mr. Grover, the eminent engineer, shows steam, *properly* used, to be 300 times as economical as animal traction. (See ¶ *a.* page 64.)

RAILWAYS AND FREE-TRADE.

TO THE EDITOR OF THE 'MANCHESTER COURIER.'

SIR,—Since the vital spark of free-trade cannot even originate until facilities for the interchange of commodities are provided—instance, isolated portions of Central India, where I found even money was not yet in general circulation—it is evident that transport plays no inconsiderable part in the free-trade question; and, moreover, no revenue can possibly accrue without it.

In fact, any obstacle to "freedom" of trade intercourse, whether it be administrative, fiscal, or physical, all deserve attention, for one and all effect in some degree the final selling price; but transport more than all the others put together.

Administratively: When, as in Turkey, the detergent effect of physical difficulties are still further enhanced by vexatious methods of collection, which frequently double the actual percentage of the dues levied; or when, as in India, the State railways are employed to tax exports (especially of bulky raw materials) by striving to earn a dividend like a private enterprise; and in the case of the East Indian, positively promoting high fares by offering the working company a share in surplus profits. In Queensland diametrically the opposite system prevails. Consequently we have ample means of judging which of the two works most in accordance with freedom of trade, and acting accordingly.

Fiscally: When protective duties are used, as they chiefly are, as counterpoises to defective means of intercommunication.

Physically: When geographical difficulties are either not palliated or removed, or performed in so costly a manner as not only to saddle the endless future with high rates of transport, but sink for a decade at least a vast amount of capital, upon the daily circulation of which our workmen of course depend. Hence the present trade depression. Cost of production, as far as labour is concerned, comes also under this latter heading; but as in the case of agricultural produce, where the rent plays but an insignificant part, so will it be found that the item of labour is but a trifle compared with transport charges.

How comes it therefore that, while daily we find contentions over fractional reductions in wages, our home railways are allowed unheeded to levy rates which according to their own showing mulct goods for tenfold the accommodation they require? The London and North-Western statistics show that, simply owing to defective organisation, a 10-ton waggon does not on an average carry more than one ton. In other words, goods are habitually treated to all the costly elbow-room of a Pullman car—a method of travelling which, even for passengers, only pays indirectly as an attraction, but certainly not *per se;* while in addition they use a sliding scale of charges which may act either protective or otherwise, according as they are lowered to favour imports or exports, a system touched upon by the Marquis of Huntly a few days since, but hardly with the determination its importance deserves.—Yours, &c.,

J. L. HADDAN.

25, *Great George Street, Westminster,*
July 7, 1879.

MILITARY RAILWAYS.

From the 'GLOBE,' *Sept.* 11, 1879.

TO THE EDITOR OF THE 'GLOBE.'

SIR,—Many a war has been undertaken solely with an eye to future business, and as a nation of shopkeepers there is no reason why our military tactics should not be designed to support this principle, especially when greater efficiency results. It would, however, be scarcely consistent with this desirable theory, if, to begin with, we destroy over one-third of the whole transport power of such portion of *our own country* as lies within a hundred miles or so of the seat of war. The loss of 60,000 camels,* the ships of the desert, means no less than £1,500,000 in hard cash to begin with, certainty of famine in the immediate future, and trade depression for a decade at least; consequent upon the loss of such a vast physically active capital—the only specie available in Eastern countries. To give some idea, however, of the local value of the loss really sustained, we might refer to the Franco-Prussian indemnity, except that in this case the victors are the victims; or we might fairly take as an equivalent one-third of the railway capital of the United Kingdom, say, £200,000,000 or so, as representing the local value of the extermination of 60,000 camels. General Hamley, moreover, has conclusively proved that the hill-tribes are robbers more from necessity than choice; and that trade, and not burning their homes, is the only sure peacemaker. It is therefore evident that trade weapons are the proper ones for men of business to fight with. A military railway rendered as handy and efficient as our more strikingly offensive weapons have been, by subjecting it to like rigorous trials and experiments; would form the most formidable weapon of offence possible, while it would perform the double duty of the sword and pruning-hook. For while enabling the blow to be struck more rapidly and effectually, and consequently more mercifully; it would likewise afford the strongest possible occupative force (a necessity when conquest outstrips our only civiliser, the lethargic railway proper) by securing the vanquished in the bonds of self-interest—the cheapest of fetters. The consequences of the loss of 60,000 of our camels, which, far more than the men, are the bread-winners of the East; will force themselves ere long on our notice, unless some equivalent *in kind* be at once provided. Money is no use; it cannot restore the dead to life, or keep the hillmen, who far more than the inhabitants of the plains depend upon transport for their daily food. We have found both in India and at the Cape, that when an ultra-civilised army, the pink of mechanical perfection, is brought face to face with primitive conditions of transport, then comes the tug of war; owing to transport, which every military man acknowledges to be the backbone of the service, being regarded as a civil commodity on which they may freely indent when requisite. At home there is some excuse for this reliance upon outsiders; but whether a campaign be undertaken at home or abroad, it is a grave commercial error to suppose that it is admissible to ruin (more or less completely) the civil transport of their own country (or of the enemy either for that matter), by either destroying its animals or monopolising its railways.

Every branch of the great military machine should be independent. Just as tons of shot and shell and regiments of Woolwich Infants must be kept in stock, with far more reason should half a million or so of portable railway be held in reserve, for the supply of the one by private firms would encourage business, while the undue interference with the regularity of the carrying trade of the railways, would in a few weeks show a national loss of millions. We have lately, even at home, had a taste of the vast power a transport monopoly affords. Make a line to Candahar, and leave Cabul out in the cold, and see if their punishment will not be far more effectual than, let us say, destroying a few

* The official number exterminated in the first part of the Afghan campaign 1878–9.

thousand or so more of our own camels in a spirited advance. A scientific frontier to deserve the name should be attained and held by science, not brute force. The telegraph having outstripped the steam-horse, makes diplomacy eat its own words, simply from want of steam legs to keep pace with lightning despatches.

Yours, &c.,

J. L. HADDAN.

25, *Great George Street, Westminster*, Sept. 10.

THE INDO-MEDITERRANEAN RAILWAY.

From the 'TIMES,' *Sept.* 24, 1879.

TO THE EDITOR OF THE 'TIMES.'

SIR,—It seems surprising that although Ministers and ex-Ministers have repeatedly shown within the last few months that trade depression is due to our capital being squandered in unsubstantial investments principally foreign; yet we find Mr. Hamilton Lang proposing to develop Turkey on the very system which is mainly responsible for it all—viz. railway guarantees. Lord Derby referred to defaulting States when he attributed trade depression to foreign loans; but the system is equally commercially rotten even when the interest is regularly paid: for until a profit is made, the interest should be deducted from capital account, which consequently might one day disappear entirely. Ex.—In India the guaranteed interest paid upon £100,000,000 has already reached £66,000,000.

Indian railways since 1858—they started in 1846—have expended in round numbers £79,000,000, and have paid in interest £22,000,000 thereon, after deducting the earnings. In other words, borrowing under a 5 per cent. guarantee, increased the cost price of the lines nearly 30 per cent., and was equal all round to a money subvention or bonus of £4000 per mile.

The guaranteed interest and capital expended during India's railway existence has been £166,000,000, upon which only £40,000,000 has been earned. The balance of £120,000,000 has, therefore, been sunk—*i.e.* withdrawn from that active circulation of capital upon which business, and especially workshop trade (England's *specialité*), entirely depends. In fact, for a time, say a decade more at least; England is poorer by this £120,000,000, just as though the investment were Bolivian, Spanish, or Turkish, and the money irretrievably lost.

We have here the result of railway finance kings acting in concert with engineer princes; who, as Mr. Lowe said at our annual dinner, were content to live upon the reputation of their fathers, whose rapid success had so intoxicated the universe that endless millions were always without question forthcoming for reproducing stereotypes of any of the works of the great English masters. The present depression will, however, let us hope, teach railway constructors and administrators that they must put themselves out to provide steam communication adapted to the wants of other countries, and not expect any longer to enjoy the halcyon days of fat commissions upon exporting *en bloc* the English railway proper; the gauge of which even chance determined, and which its inventor, George Stephenson, always declared to be out of its element in even moderately mountainous countries; having been primarily designed by him to compete with canals—on the level.

Your correspondents, Mr. Lang and Mr. Austin, advocate Tripoli as a *point de départ* for the Indo-Mediterranean Railway, simply for the *primâ facie* forcible reason that it is the easiest line of country; and thus prove by their choice that the Stephenson railway is quite out of place in Syria, since it must bow to every trifling physical obstacle, instead of commanding its own route under the guidance of purely commercial considerations only: thereby changing the trade routes and interests established for centuries, and upsetting everybody, simply to suit contractors' notions of railway construction.

A Turkish railway, and I speak from experience, should possess the military faculty which Sir Garnet Wolseley insists upon—viz. of obeying orders and going anywhere, following the mule tracks traced by the experience of ages, and not by the hasty hand of some freshly-imported engineer; in direct contradistinction to the ordinary railway, which, after exacting all sorts of physical and financial concessions as tributes to its inherent weaknesses, cannot, even when started as Mr. Lang suggests—one little stage, say as far as Aleppo—take another feeble step forward on its own bottom, under a quarter of a century at least. Ex.—The Indian Government have not the means of completing their railways after working thirty years on the guarantee system, and spending £114,000,000; how, therefore, can Turkey hope to fare better? It is surely wiser to face the difficulty boldly, for necessity can and has provided a remedy.

Engineers have not, thanks to financiers, hitherto had any call to exert themselves to produce ready-money railways, capable, like all other sound investments, of earning their own living, and procreating themselves by turning over their capital; but it will be entirely the fault of so-called men of business, if they do not exact from engineers that they shall do their duty in always providing markets for our products, by properly employing at least a portion of the 300-fold margin which steam theoretically maintains over horses: in face of the fact that we can any day ride farther in a tram for less money than we can by rail: while inland goods are handicapped by extravagant railway freights—the only item in the selling price which does not accommodate itself to the invariable law of supply and demand.

All the various distinguished travellers acquainted with Syria maintain there is considerable business activity—Captain Burton, who would renew Tyre's ancient glories; Commander Cameron, who is smitten with Tripoli as a feasible port; and lastly, not least, Mrs. Brassey, who thinks donkey-back travelling hardly good enough for the Holy Land; nor is it.

But putting together all their valuable information, combined with my own, obtained during a long residence as engineer-in-chief of these provinces; I find even the trunk routes cannot afford a larger capital expenditure per mile than £1000: on which amount a dividend of about six per cent. is absolutely certain.

I would, moreover, draw the attention of our Government to the patent fact that the Turkish Empire cannot be reformed by diplomacy, the great distances involved rendering the strongest arm valueless; but organization of the existing means of communication previous to the introduction of railways will revive trade, pay its own way, and through its endless ramifications introduce a subtle power of control, none the less tangible because it works *sub rosâ*—the only way to steer clear of the overweening pride of the Turkish governing race, which always so dexterously converts any European interference into coals of fire piled upon the unfortunate head of the broad-daylight reformer. From engineers they will accept instruction, but in diplomacy they consider they require no teaching.*

J. L. HADDAN.

25, *Great George Street, Westminster*, Sept. 19.

* See Turkish Reforms, page 36.

EXTRACT FROM A REPORT ON THE PIONEER SYSTEM BY J. W. GROVER, M. INST. C.E.

a. Now to sum up the combined advantages therefore of an engine on a level railway, against a horse on a level common road at ten miles an hour, we shall find that the former gives an economy over the latter of nearly 300 to 1.

b. In the autumn of 1869 the 'Times' took up the railway problem, but though advocated by so powerful a pen the reforms still remain unaccomplished —indeed uncommenced. It was then shown that in practice every passenger on a railway involved over two tons of iron and timber to carry him—or about 95 per cent. of dead weight. Mr. Haddan's system gives a paying load one fourth greater than the dead load.

c. When a little branch railway has to be constructed why should the country expect a scale of magnificence in works and stations like that upon the main line from London to Liverpool? why should the undertaking be saddled with bankruptcy from its inception and what is beneficial in itself, be converted into a bye-word? *The fact is that the world, not excepting engineers themselves, has been educated up to a certain standard of requirements; and hence it is absolutely hopeless to look for any change in England in Railways as we understand them.*

d. A "Light" Railway is a misnomer—a term which has led to a great deal of confusion and loss of money—a "light" Railway must necessarily be a bad railway. The main line manager finds all the gradients have been made too steep and the curves too sharp—to avoid expensive earthworks—a manœuvre which actually involves even *heavier* permanent way than he is using on his main line. In fact the line has to be remade.

Engineers have freely acknowledged that a branch line must be absolutely something different from the parent stem, and Traffic managers for different reasons, hold the same opinion.

e. The Little Festiniog Railway in North Wales has been frequently illustrated in support of the arguments for an extremely narrow line, for though only two feet wide between the rails it has paid dividends exceeding 12 per cent.—that it has been assumed somewhat hastily that the dividend varies inversely as the gauge, and that by halving the width between the rails, the profits can be doubled. The fallacy of this argument is proved at Festiniog itself, for there even on the face of the same mountains is another line, not a branch of the first, but rather its continuation to the village of Festiniog, which though worked and made by an independent company has returned no dividend to its shareholders.

f. In how many parts of England, Scotland, and Ireland, but more especially the Colonies, which are languishing for want of humble but efficient steam ways—how enormously might the productive powers of the soil be increased by easy access to and from the railway system, so that every farmer might have heavy freight brought to his homestead, giving him cheap lime, coal, and manure against his produce, hay, straw and cattle; and furthermore what a field is here opened out for the investment of capital now seeking employment and only finding it in foreign enterprises!

g. My first reason in advocating Mr. Haddan's system is founded on the great difficulties which cuttings and embankments offer to even the simplest form of narrow gauge Railway construction, difficulties only known to those who have to deal with them in practice. So great are they in foreign lands where labour is difficult to get, and contractors with sufficient plant are wanting; that the fashion now obtains amongst engineers of making the line meander round the hills in

very serpentine courses—thereby enormously increasing the length of the line, and involving sharpness of curve, which would have shocked the original inventor of Railways. The constant tendency to sharpen the curve and increase the gradient—show the false direction to which the wants of civilisation are urging engineers from year to year.

g.g. I laid out a line to Caracas, the capital of Venezuela, which is only a distance of eight miles as the crow flies. My line was twenty-three miles long, and for works alone the narrow gauge contemplated would have cost £16,000 per mile.

Mr. Haddan could serve this city with a line only ten miles long, and running at half the speed could perform the journey in less time; and when we come to take his capital expenditure into account, the enormous magnitude of the advantage becomes manifest.

h. Now with respect to gradient—Mr. Haddan's system contemplates connecting the whole of the wheels of the train by means of an endless rope, theoretically therefore he could work gradients from 1 in 4 to 1 in 6, say in practice 1 in 10. With such a gradient he could go anywhere, and by the facility the endless rope affords of applying continuous brake power, he could descend that gradient successfully and safely.

i. Whether crossing a plain or ascending the side of a mountain, or valley, on sidelong ground, the difficulty with earthwork is great, because the natural drainage of the country is interrupted, and frequent culverts and costly bridges must be provided to allow streams and flood waters to get through. Take for instance the plains of Hungary, which seem to the unpractised eye to offer great material facilities for level and easy Railway construction. There I found that the rails have to be carried on artificial continuous embankments six or seven feet high, and frequently in the vicinity of flooding rivers there have to be long viaducts involving immense cost; or else (as at Szegdin) lofty dam banks entailing a standing menace to life and property. (See the Emperor of Austria's speech, *Times*, May 19.)

In Mr. Haddan's system the constructed track really forms its own bridges and culverts, and is also a permanent way; it requires no road bed and is therefore best adaptable to the conformation of uneven countries. By my estimate it will be found that the entire Pioneer track can be executed for less than the permanent way of an ordinary "light" 4-8½ gauge.

k. I cannot avoid in conclusion repeating that there is a want of something less costly and *weighty* than now exists; and although the Haddan system can never be set up to do the work done by a modern Railway, it can go into places where the present generation could never hope to see an ordinary railway.

NOTICE TO CORRESPONDENTS.

MESSRS. HERBERT AND COMPANY are now in a position to accept orders; having obtained guarantees from the makers as to both the performance of the rolling-stock and the stability and endurance of the road. To afford confidence to intending purchasers or lessees in distant countries, the following advantageous terms are offered.

The *first* ten miles to be paid for in cash, the remainder on deferred payments, if desired. They undertake to supply the Pioneer road in iron complete (suitable for any grade not exceeding 1 in 20, or curve of 100 feet radius) together with locomotives in running order; each supplied with a train of thirty composite waggons constructed to carry either 60 tons net or 240 passengers, or any desired proportion of each.

	£
The *first* ten miles, as above, including two trains; provisionally erected in this country, and tested to purchasers' engineer's* satisfaction. Shipped. Price, f.o.b.	20,000
Every additional mile in iron, f.o.b.	1,000
Proportionate rolling-stock, per mile	200
For military purposes—grades 1 in 10, curves 30 feet radius, road in Landore Siemens' steel—per mile, f.o.b.	2,000
Extra powerful Locomotives for military purposes—each	1,000

The Pioneer Company will also construct and work lines at entirely their own cost, provided a daily tonnage equal to 200 tons is guaranteed. (See page 23.)

67, *Strand, London, England,*
November 1, 1879.

* The "Pioneer" Consulting Engineer in England is Mr. J. W. Grover, M. Inst. C.E., of 9, Victoria Chambers, a gentleman of great experience in the laying out and construction of mountain railways in various parts of the world. A copy of his detailed report, may be obtained on application; but a few extracts are given on pages 64 and 65.

LONDON: PRINTED BY WILLIAM [illegible] AND SONS, STAMFORD STREET, AND CHARING CROSS.

UNITED SERVICE INSTITUTION OF INDIA, SIMLA.
Acc. No. 1275
Dated 25-5-54

Acc. No. M-1275
Class No. 358.261 Book No. HAD
Author Haddan, J.L
Title The pioneer or Steam Caravan



